CHEMISTRY

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Uranium Prospecting 1
Back Cover Picture:
Pitchblende Vein 12
Dr. R. A. Millikan on Uranium 13
Actinium By Transmutation 18
Classic of Chemistry:
Discovery of Actinium 19
Tag! 21
Radioactive Iodine Measured 24
At a Safe Distance 25
A Cascade of Fire 26
For the Home Lab:
Methyl Orange 27
Positive Ion Nose for Gases 29
Current Chemical Research 30
Rat-Killing Chemicals 44

Editorial:
The Problem of Atomic Power
Inside Front Cover

25¢

The Problem of Atomic Power

➤ DR. MILLIKAN'S views on atomic power, given in his radio broadcast reproduced in this issue of CHEMISTRY, concern a subject that continues to be of paramount importance year after year. One of the trustees of Science Service who had a mike-side seat at the Science Service annual meeting was Frank R. Ford, editor of the Evansville, Indiana, Press. Mr. Ford found the Millikan broadcast "tremendously important" and analyzed its implications as follows:

"1. Atomic fission will not be used to create industrial power because it is too expensive and will continue to be too expensive.

"a. If this is true haven't we had a lot of wholly whimsical hokum on the subject? The worry over monopolistic control of this new, cheap source of power, the prospect of developing economically backward countries, etc.

"b. If this is a sound conclusion and other qualified scientists are in agreement, isn't this statement sensational in the extreme and shouldn't it be developed extensively?

"2. Atomic power will be used in war, because in war you don't care about costs and, in medicine, because you don't care much.

"a. If this be true, should atomic development not be the primary concern of the military and the medical profession?

"b. How much of our vast expense in work with the atoms is based upon the assumption of economic (industrial) value and is it possible that such expenditures are wasted?"

Scientists and laymen alike may not agree with Mr. Ford that atomic matters should not be the concern of everyone, civilians as well as the military, and all scientists as well as the medical scientists. Everyone is affected by the results of atomic fission, even if uranium is too precious to be used for commercial power.

Thanks to Trustee-Editor Ford for writing our editorial this month.

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➤ HE LISTENS *to the uranium which tells him, through the portable Geiger counter he wears, in which pieces of ore it is entrapped. Modern accouterments give the uranium prospector a "new look."*

Uranium Prospecting

by HUGH S. SPENCE
Canadian Bureau of Mines, Ottawa.

The Canadian Government, through its Bureau of Mines, has issued this information on how uranium minerals occur and how to look for them. Great Bear Lake in northwestern Canada has rich uranium deposits.

➤ THE NUMBER of known minerals which contain uranium in some amount is quite large — over fifty species are listed — but the great majority of these are rare and can be considered at present of only mineralogical or specimen interest. In many, also, the uranium present is not an

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essential constituent, but is more in the nature of an accidental impurity, and the content of the element is so low and so variable that these minerals are of small practical importance as a source of uranium. Even at this time, when there is such a live interest in even low grade uranium ores, such minerals are likely to be of little value as an economic source of the element, and it would be unwise to spend time and money in prospecting for them or in attempting to mine for them, if found.

The bulk of the world supply of uranium up to the present has been obtained from deposits of the following minerals:

Pitchblende, and secondary alteration products of

Carnotite - Tyuyamunite

Autunite - Torbernite

Of these, only pitchblende is a primary mineral. The others are of secondary origin, and have been deposited through the agency of circulating waters at or near surface, or are the result of weathering in place of original pitchblende.

Primary Minerals

Primary uranium minerals are dominantly black, conspicuously heavy, and of a metallic or sub-metallic appearance.

Pitchblende, the richest and most important, is compact and massive, with no evidence of crystal form or structure. It sometimes is found with botryoidal, or kidney-like, surfaces and a radiated texture. Pitchblende is distinctly a vein-forming mineral, and is usually associated with cobalt, nickel, silver, and copper.

Almost all of the other primary uranium minerals, including *uraninite*, a crystal variety of pitchblende, are confined in their occurrence to granitic rocks, more especially to pegmatite, which is a "giant," dyke-forming type of granite in which the chief component minerals, feldspar, mica, and quartz, occur in large crystals or masses. The variety of uranium minerals found in such association is large, and for the most part these are of complex compositions, being multiple oxides of uranium, tantalum, columbium, titanium, iron and the rare-earth elements. They are mostly black to dark brownish-red in color, conspicuously heavy, often of a sub-metallic appearance, and usually occur in the form of well-developed crystals up to several inches in length. It is characteristic of such minerals that the rock enclosing them is usually stained or coloured a deep brownish-red, and any patches or zones of conspicuously reddish colour in a pale pegmatite groundmass are worthy of examination for the possible presence of uranium minerals. Sometimes, also, small traces of conspicuously coloured canary-yellow or orange powdery crusts of secondary uranium minerals occur surrounding such crystals and serve to confirm their nature. It is not uncommon for pegmatitic uranium minerals to be concentrated in zones containing large nests or aggregates of black mica, and the rock around such mica, as well as the mica crystals or books, themselves, should be given particular examination. The occurrence, also, of a black, coal-like hydrocarbon mineral (thucholite or anthraxolite), which will burn, in a pegmatite is suggestive of the presence of uranium, and this material

➤ RADIOACTIVE *fractions from the uranium minerals are concentrated in these evaporators at the Port Hope Refinery of the Eldorado Gold Mines in Canada's Northwest Territories.*

itself, often contains a considerable amount of the element.

As a rule, such minerals occur rather sparsely disseminated in the host rock, though occasionally they form small nests or pockets. Owing to their complex composition, which would make chemical treatment for recovery of the contained uranium difficult and expensive, their variable and often only small content of uranium, and the usually limited quantity present, they can be considered as of only problematic value as uranium ores. However, it is of decided interest to have all new discoveries of such minerals placed on record, in case it may prove desirable to have the occurrences investigated more thoroughly at a future date.

Primary uranium minerals are rather prone to alteration and breakdown under weathering agencies, and for this reason they are seldom likely to be found with their fresh outward characteristics preserved in surface outcrops. Many of the species found in pegmatites tend to become externally friable and coated with a rusty crust, when severely weathered, due to oxidation of the contained iron. Pitchblende, as well as its variety uraninite, may weather to a greenish cast, and both are more liable to ex-

hibit characteristic and vividly coloured yellow and orange secondary alteration products.

The foregoing remarks apply more specifically to conditions as they are likely to exist in Canada. In regions of deep weathering, as in tropical countries, it is common for most primary uranium minerals to suffer a complete alteration, in place, to secondary compounds. Certain Madagascar pegmatitic species are usually heavily altered to a yellow powder: the same holds for uraninite from Tanganyika: and at the famous pitchblende deposit in the Belgian Congo, the veins were found to be almost completely oxidized to a considerable depth, with the formation of ore consisting of a wide variety of spectacular and brilliantly coloured uranium compounds.

Possibly owing to ease of weathering, primary uranium minerals do not commonly form placer deposits, and few instances of such occurrences are known. However, some sections of the Rand banket conglomerate, in South Africa, have been found to carry detrital grains of *uraninite*, or *pitchblende*; and placer deposits of thorianite, a thorium mineral containing considerable uranium, occur in Ceylon. Any beach or river sands containing an important amount of heavy black minerals are worth investigating for the possible presence of uranium/thorium minerals. (See also below, under *Monazite*.)

Since, through surface weathering, pitchblende may break down into a variety of secondary uranium alteration products, all of which exhibit extremely brilliant and characteristic yellow, orange, or green colours, such compounds noted in a vein outcrop or gossan, offer definite evidence of the presence of pitchblende at depth.

Pitchblende frequently is associated with cobalt-nickel-arsenic minerals, which also weather readily to form characteristically coloured pink (cobalt) and green (nickel) powdery alteration products. The association of a heavy, massive black mineral with such compounds may be taken as strongly suggestive that the former is pitchblende.

Secondary Minerals

As already stated, deposits of secondary uranium minerals have originated through the precipitation of uranium salts derived from primary minerals and carried in solution by surface or circulating waters. The minerals formed in this way are mainly compounds of uranium with such other elements as calcium, copper, lead, vanadium, etc.

Only rarely, as in the case of the famous occurrence in the Belgian Congo, have such minerals been found as a rich replacement in situ of primary ore. More usually, they have been deposited in rather sparse amount on cracks, joints, or solution channels in rocks which either originally contained primary minerals or which occur overlying or adjacent to occurrences at depth of such minerals. Occasionally, deposits of this last type have proved rich enough to work for their uranium content, as in Portugal, Russia, and Australia. If carried in solution by surface waters into basins or other favourable catchment areas, uranium salts may be deposited as rich concentrations of secondary min-

erals. In such event, carbonaceous matter in the form of decaying vegetation (or oil) is particularly favourable to deposition, as in the case of the *carnotite* occurrences in Colorado and Utah, the uraniferous peaty muds of Madagascar, and the lignitic 'kolm' of Sweden.

The bright and extremely characteristic yellow, orange, or green colour of most secondary uranium minerals serves to attract attention to them, and is the most ready means of visual identification. Since such minerals are formed most often in hot, arid, or tropical regions, it is regarded as unlikely that important concentrations of them will be found to occur in a heavily glaciated country such as Canada. Even small traces of them, however, may prove of value as indicating the possible presence of richer primary ore at depth.

Thorium Minerals

It is not uncommon for certain primary uranium minerals, more especially those found in pegmatites, to contain moderate amounts of thorium. Certain varieties of *uraninite*, the crystal form of pitchblende found only in pegmatites, are fairly rich in thorium, but, on the whole, straight thorium minerals which might be regarded as commercial sources of the element are much less common than uranium minerals and only a few are known. Most of even these few are of rare occurrence and of only mineralogical interest, and up to the present practically the entire world supply of thorium has been obtained from the single mineral *Monazite*.

Monazite

Monazite is of complex composition, consisting mainly of cerium and other rare-earth elements, with up to 18 per cent of thorium. It is a non-metallic mineral, yellow to reddish brown in colour, conspicuously heavy, and of crystalline character. It occurs as tabular crystals in pegmatite dykes, and as small grains in rocks intruded by granite or pegmatite, but most of the commercial supply is obtained from rich concentrations formed by wave action in beach sands along the coasts of India, Brazil, and Australia. Similar beach deposits are known in Ceylon, Florida, Malay, and the Netherlands Indies, all of which have furnished small quantities.

It is doubtful if occurrences of monazite in rock would be of economic interest at the present time, but such occurrences are worthy of record and might be of value as indicating the possible presence of nearby placer deposits, particularly if they exist in coastal areas.

Any extensive beach sand areas conspicuously rich in heavy black minerals are worthy of sampling for a possible monazite content. The black metallic mineral in such sands is likely to be *ilmenite*, an important ore of titanium, and often associated with it are *rutile* and *zircon*, both valuable industrial minerals.

Other Thorium Minerals

The richest thorium mineral known is *thorianite*, a heavy, black metallic mineral which occurs in small cubic crystals in pegmatites. It is known in commercial amounts only in alluvial

placer deposits, and is an exceedingly rare mineral, whose principal source is Ceylon.

Allanite is a complex mineral containing cerium and other rare earth elements; it may carry up to 3 per cent thorium. Its occurrence is confined to pegmatites and granite, and in the former it is sometimes found in very large crystals. Allanite is a heavy, non-metallic mineral, black when fresh, but usually altered externally to a brown colour. An outer brown and friable crust is typical for allanite, and usually serves as a ready means of identifying it. While allanite has not so far come into consideration as a commercial source of thorium, it might serve as such if found in sufficiently rich deposits. For this reason any new discoveries of the mineral are worth placing on record.

Thorium is not precipitated out of solution in circulating waters, as is uranium, and hence important deposits of secondary thorium minerals are unknown, or are of relatively small importance. Small traces of thorium occur in the sinter of certain radioactive springs in Germany, France, and other countries, and in some cases recovery of thorium has been made from such sources. In view of the relative abundance of monazite, however, this mineral, as well as perhaps other primary thorium minerals, originating in pegmatitic or granitic rocks, is likely to remain, for the present at least, the most important source of the element.

Aids in Identifying Minerals

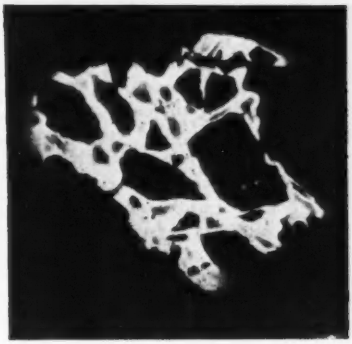
General, broad information on the character and mode of occurrence of uranium/thorium minerals has been given in the preceding section. Such information will serve as a guide to the main distinguishing features of such minerals and to the type of formation or rock in which they are likely to be found and where they should be looked for.

The following notes in part present a resume of what has already been said, with emphasis on the principal outward characteristics of the minerals, add a few more details that may aid in their visual identification, and, in addition, outline more definite means for determining their nature.

Pegmatitic minerals that contain uranium/thorium, in amounts ranging from small traces to substantial amounts, may exhibit a metallic or non-metallic character and appearance. Often, it may be difficult to decide off-hand into which of these categories a particular unknown mineral should be placed, since many black species appear to be metallic, and only on examination of small fragments under a strong lens or a microscope does their non-metallic nature become apparent. This is evidenced by the fact that thin chips or splinters are translucent, usually exhibiting a characteristic red or brown colour, even though the massive mineral itself may appear opaque.

In general, it may be said that any conspicuously heavy, black or dark-coloured minerals discovered in a pegmatite should be tested for possible uranium/thorium content. Such minerals may be difficult to distinguish visually from *magnetite* and *ilmenite*

▶ ORE CONTAINING *veins of pitchblende surrounding rock fragments. This specimen was found at Great Bear Lake, Canada.*



▶ THE URANIUM *in the lump of ore shown in the picture above imprinted its own signature on the photographic plate.*

—both common in pegmatites—or from rarer *tantalite-columbite, wolframite,* and *cassiterite*. Greater weight serves to distinguish them from *black tourmaline*, one of the commonest dark-coloured pegmatite minerals, and from also *hornblende*.

Pegmatitic uranium/thorium minerals usually, though not always, occur as well-formed crystals, which may be of cubic, prismatic, or tabular form. In general, such crystals do not measure much over 3 x 1 inches in size. They may occur as single scattered individuals, but usually they tend to be concentrated in localized groups or zones.

The presence of a bright yellow or orange crust or powder surrounding a dark mineral is almost conclusive evidence that it contains uranium; and small plates or scales of a yellow or emerald green colour on cracks and joints in a rock are a useful indicator of nearby primary uranium ore.

In dykes composed of pink or red feldspar, the colour of the spar around uranium/thorium minerals is usually of a conspicuously darker brick-red shade; in white feldspar dykes, such minerals often cause a brownish or black discolouration in the enclosing rock.

A conspicuous radial fracturing of the feldspar or quartz surrounding a mineral inclusion in pegmatite rock is also often a useful indication that the inclusion contains uranium/thorium. *Cyrtolite*, a variety of *zircon*, which often contains small amounts of uranium/thorium, is particularly prone to exert a pronounced shattering effect in its host rock, and even small crystals may give rise to strong cracks radiating outward several feet from them.

Pitchblende

As already stated, pitchblende is the only uranium mineral known to occur in the form of definite veins or lodes. It may be difficult to identify with any certainty by its outward characteristics; when relatively pure, however, its exceptional weight serves to suggest its nature. The absence of any indications of crystalline or grain structure, or of cleavage, is helpful, the mineral breaking with a smooth, irregular, fracture and having a dull, somewhat greasy or pitchy appearance or lustre. It sometimes occurs in botryoidal, or kidney-like masses, or crusts, which under a lens are seen to have radiated structure. In this last form, pitchblende somewhat resembles hematite iron, but it may readily be distinguished from hematite by the black or greenish black colour of its streak or powder, which for hematite are a strong red.

Secondary Minerals

Secondary uranium minerals are those formed by the alteration of primary species by weathering or other natural agencies. They may be found replacing the original minerals in situ, but more commonly have been precipitated out of solutions derived from such minerals.

Deposition may have occurred adjacent to the primary source, on cracks and joints in the enclosing rock; or the dissolved salts may have been carried considerable distances by circulation or surface waters, with the formation of rich concentrations in certain favourable areas. The *torbernite-autunite* deposits of South Australia and Portugal are examples of the first type of deposition, and the second type is represented by the *carnotite* occurrences in Colorado and Utah.

As a general thing, a tropical, or a hot and arid, climate is necessary for the formation of important deposits of secondary uranium minerals, and it is unlikely that occurrences of this nature will be found in Canada, where recent glaciation has removed much of the original surface. However, such minerals are important in that they may serve, even in small traces, as indicators of the possible nearby presence of primary ore, and accordingly they are briefly mentioned here.

The only two species commonly exhibiting crystal form are the so-called 'uranium micas,' *torbernite* and *autunite*. These occur in small brittle, cleavable plates which for *torbernite* are of an *emerald green colour*, and for *autunite* are *bright lemon yellow*.

The other species for the most part occur as either powdery coatings or soft massive material made up of exceedingly fine particles. Intense and vivid colours, in shades of bright yellow, orange, and green, are the chief distinguishing features of such minerals and serve at once to attract attention to them. Most of them are salts of uranium and various other metals, and a large number of such minerals are known.

Mode of Occurrence

Summarizing what has been said above, the following are the main points to be noted in connection with the mode of occurrence of uranium minerals.

Broadly speaking, the occurrences may be divided into the following three main types:

(1) Individual crystals, or nests,

pockets, or similar aggregates of crystals—usually of small size and extent—sparsely and irregularly scattered through dykes of *granite pegmatite*. The variety of uranium minerals occurring in this manner is large, and embraces a large proportion of the known species.

Distinguishing characteristics of such minerals are black colour, metallic appearance, heaviness, and good crystal form.

(2) *Veins, or lodes*, of similar character to the general run of those of other metallic minerals such as zinc, lead, copper, etc. *Pitchblende*, the richest and commercially the most important ore of uranium, is the only primary uranium mineral that occurs in deposits of this type. It may be the dominant mineral, or, as is sometimes the case, be in the nature of an accessory in veins of other metallic ores, notably those of silver, cobalt, and nickel. Pitchblende is characterized by black colour, metallic appearance, greasy or pitchy lustre and dense, massive texture. It never exhibits crystal form, but sometimes occurs in layers or bands having botryoidal or kidney-like surfaces.

(3) Deposits of a *bedded, replacement, or stockwork* character, in which the uranium minerals are a minor constituent of secondary origin and nature and have been emplaced through the agency of surface or circulating waters. Occurrences of this type may be found in both sedimentary and igneous (granitic) rocks, and usually they carry little, if any, trace of primary uranium minerals.

Secondary uranium minerals found in such deposits are characterized by vivid and brilliant colours in tones of yellow, orange, or green. They are usually in the form of soft powder, crusts, or tufts, occasionally being more massive. They seldom exhibit distinguishable crystal form, except in the case of the two commoner species, *torbernite* and *autunite*, which occur in small well-developed thin plates.

Radioactivity Methods

All minerals containing uranium/thorium are radioactive; that is, they emit energy in the form of spontaneous radiation, and this may be detected by several fairly simple means. It is not possible, however, to distinguish between the emission from the two elements except by precise laboratory methods. Close geochemical affinity, also, exists between the uranium and thorium, and many minerals containing either element—more especially the pegmatitic species—frequently carry the other as well, in which case the radiation is of a dual nature, and may lead to wrong conclusions being drawn.

Photography—One of the simplest means for detecting radiation from minerals is to place the specimen on an ordinary photographic plate or film in a light-tight box and allow it to remain undisturbed for about 36 to 48 hours. On developing the negative, any marked uranium/thorium content will be evidenced by a distinct image, or auto-radiograph of the specimen. Intensity of such image, or self-photograph, is a rough measure of the degree of radioactivity of the mineral, and thus of the amount of uranium/thorium present. This amount, in turn, governs the time of exposure required to produce a well-defined

picture. To avoid possible misleading effects due to pressure or chemical action on the photographic emulsion, it is sometimes advised to interpose a thin sheet of paper between the specimen and the film. Production of a smooth face on the specimen by sawing or grinding is advantageous and results in a much clearer and more defined image being formed.

Recent refinements in the making of radiographs of mineral specimens employ a special type of light-desensitized film. This distinguishes between uranium and thorium radiation, when both elements are present, by the relative intensity of the image.

Visual—For many years, a simple means of detecting radioactivity in minerals in the field was by the use of a small pocket device known as a *spinthariscope*, or *scintilliscope*. This consists of a short brass tube provided with a cap bored with a small hole in which a magnifying lens is inserted. Below the lens is cemented a small square glass prism, the lower end of which is coated with zinc sulphide powder. If a small fragment of strongly radioactive mineral is held close to this coated surface, some of the radioactive particles emitted impinge on the grains of powder and cause a succession of momentary flashes of light, readily seen through the lens. For best effect, it is necessary to conduct the experiment in a dark place, and to have the observer's vision thoroughly adjusted to darkness for a period of several minutes.

One of the most reliable and widely-used instruments for detecting and measuring radioactivity has long been the *gold-leaf electroscope*. This makes use of the property possessed by radioactive materials of releasing the electrical charge on two small strips of gold leaf through ionization of the air in a small chamber in which they are suspended. By comparing the rate of discharge effected by a measured quantity of powdered and carefully sized material made from an unknown sample with that produced by a similar amount of a standard of known composition, a fairly close and rapid estimate of the degree of activity, and hence of the uranium content, of the test sample can be made. By such means, a great deal of time-consuming chemical analytical work can be eliminated, particularly in mills and refineries engaged in producing and treating uranium ores. Any thorium present in the test samples of course destroys the efficiency of the method, since thorium is much more active than uranium. For reliable results, the electroscope requires to be employed in a laboratory and is hardly suited to field use.

It is sometimes stated that the portable *ultraviolet light lamp* is a useful tool in prospecting for uranium minerals. This is true to a limited extent only, since only certain of the secondary species, and none of the richer primary minerals, exhibit any fluorescence under ultraviolet light, whether short or long wave. The utility of the lamp, therefore, would be confined to a few fluorescent secondary minerals, only one of which—*autunite*—has so far been found to occur in sufficient quantity to be of any particular economic interest. Accordingly, for practical purposes, prospecting for ura-

nium mineral deposits by fluorescent means is not to be recommended, particularly as we now have a much more simple and practical tool for detecting even small traces of uranium/thorium minerals in the instrument described below.

Electronics—The above-mentioned, and, by comparison, relatively crude means of detecting or measuring radioactivity in minerals or other substances have more recently been supplanted by much more delicate and precise methods provided by an instrument known as the *Geiger counter*. This is a device employing radionic principles, whereby radioactive emission can be directly registered, measured, and recorded, either in the form of sound or in other ways.

For field use on minerals, either broken out as specimens or in place, small portable, light-weight units, equipped with dials, ear-phones, or built-in amplifiers, have recently become available and are proving of considerable value to prospectors engaged in a search for uranium/thorium ores.

In its original, rather cumbersome form, the instrument has long been employed with conspicuous success for locating radium lost or mislaid by hospitals and doctors, and numerous instances of recovery of valuable radium from such locations as garbage dumps, incinerators, drains, etc., by its use are on record.

Development of more elaborate laboratory instruments of this type have now reached a stage where, with the aid of known standards, very precise measurements of uranium/thorium can be made, thus dispensing entirely with the need for chemical analysis and giving results in only a fraction of the time formerly required. Even greater refinements are possessed by models capable of registering selectively the radiation from uranium and thorium, thus establishing which element is responsible for the radioactivity of a mineral, and, if both are present, the relative amounts of each.

It might be noted that the portable type of Geiger counter, designed for prospecting use is essentially a detecting, and not a measuring, instrument. It will register even small increases in the radioactivity of minerals and rocks above the normal count, and will indicate either by sound or dial reading whether a specimen or area is "hot." Within limits, it will indicate the *degree* of radioactivity up to a certain point, thus enabling material or ground to be selected for recording and more detailed examination later. It cannot be used, however, to give even a rough approximation of the actual amount of uranium/thorium present, since various factors may confuse the issue.

Portable counters are of fairly rugged construction, and can be packed around with little risk of damage, provided reasonable care is exercised. Details of operation are readily acquired and call for no special skill or training. With a little experience, and with proper recognition of their limitations, they provide an indispensable tool for the prospector undertaking a search for uranium/thorium minerals.

Guatemala's production of volatile oils from highly scented grasses is one of its important agricultural industries.

Thorium Mineral Research Needed

➤ MORE RESEARCH on monazite, the leading source of thorium, which can be used with uranium in a chain-reacting pile, is one of ten "top priority" projects listed by geologists.

An 11-man committee of the Council of the Society of Economic Geologists made a poll which is reported in the journal, *Economic Geology*. Joseph L. Gillson, chief geologist of the E. I. DuPont deNemours Company, and Richard H. Jahns, professor of mineralogy at the California Institute of Technology, reported that the top ten suggestions made in the poll were:

1. More detailed study of individual mineral deposits.

2. Mapping detailed areas of regions in which deposits of industrial minerals are abundant.

3. Sediment studies to understand more fully the beginnings of deposits laid down by water, wind and ice.

4. Experiments on the synthesis of minerals.

5. Studies at high temperatures and pressures.

6. Further development of techniques for spectrum studies to discover minute quantities of metals or rare elements in rocks and minerals and also to detect hidden deposits of ores nearby.

7. More intensive study of clay minerals.

8. Additional research on monazite and deposits of monazite.

9. Trace-element studies to attempt to find mineral deposits, particularly of fission or atomic minerals, and geochemical studies for new methods of prospecting.

10. Zoning studies of non-metallic mineral deposits.

Quick Uranium Assay

➤ THE QUICKEST WAY of estimating the amount of uranium in an ore is to compress the mineral into a small pill and then measure its radioactivity with a Geiger counter, according to Dr. Clement J. Rodden of the National Bureau of Standards. He spoke before the Washington Chemical Society, pointing out that the recent offer of the Atomic Energy Commission of $10,000 for the discovery of new sources of the metal has stimulated interest in assaying uranium.

On the Back Cover

➤ URANIUM *and silver come from this pitchblende vein in Canada's Labine Point area. How to recognize minerals containing the modern precious metals, uranium and thorium, is the problem of today's prospectors. All photographs in this series from the Canadian National Film Board, Department of Mines and Resources.*

"Atomic Energy Element Should Not Be Used for Major Power Purposes"

Dr. R. A. Millikan On Uranium

▶ AT THE 28TH *annual meeting of the Board of Trustees of Science Service held in Philadelphia April 24, Dr. R. A. Millikan was the speaker on the Science Service program over the nation-wide network of the Columbia Broadcasting System. Because of the vital importance of his views on uranium and atomic energy,* CHEMISTRY *publishes the major portion of the script, with introduction by Dr. Harlow Shapley, Harvard astronomer and president of Science Service, and questions by Watson Davis, director of Science Service.*

SHAPLEY: When the founder of Science Service, the late E. W. Scripps, discussed with scientists nearly thirty years ago the idea of Science Service, one of his principal consultants was Dr. Robert Andrews Millikan, of the California Institute of Technology. During the whole existence of Science Service, Dr. Millikan has been a trustee, and today our board of trustees has thanked him in formal resolution on behalf of the scientific world for his consistent and helpful participation in the great task of taking science to the people.

DAVIS: Our Adventures in Science guest today is, most fittingly, Dr. Robert Andrews Millikan who has been a trustee of Science Service since the beginning of its work in 1921. Dr. Millikan is a great scientist, a Nobelist in physics, who for many years was head of the California Institute of Technology. His studies of cosmic rays have been classic, and a few weeks from now the physicists of the country will be holding a scientific meeting in his honor in Pasadena to discuss the present knowledge of cosmic rays. Dr. Millikan has been in the forefront of physical investigations during this century. As a matter of fact, it was just after the turn of the century that Dr. Millikan began working on uranium because of its radioactivity. It's very natural, therefore, Dr. Millikan, that we ask you what you think about the importance of uranium today in connection with the release of atomic energy from it.

MILLIKAN: The greatest service to mankind of the atomic bomb and atomic energy would be to make clear as crystal to all classes and conditions of men the world over the necessity for eliminating aggressive war. This is more true today than it ever was. War profits no one, victor or vanquished. As soon as that is made clear to the great majority of mankind, everyone who is rational or intelligent, or even has any instinct of self-preservation, must and will find a way to save himself from annihilation.

DAVIS: Won't the obtaining of peacetime power from atomic energy be very important, Dr. Millikan?

MILLIKAN: Industrial applications of atomic power such as was released by the fission or disintegration of uranium in the atomic bomb will be wholly negligible in compari-

son with the necessity that it places upon all mankind to find a substitute for war. As a matter of fact, the amount of power that we can get out of uranium is very limited indeed in comparison with the amount available to us from sunlight past and present. Uranium, and even thorium, from which fissionable materials can be made, is a very rare element in the crust of the earth, its average concentration there being by weight about six parts in a million. If you don't care how much power costs, as is the case in wartime and more or less so in the cure of disease or in a very limited number of other cases, then the heavy unstable atoms will doubtless find a place as power producers. But even then it will be a relatively small place, since the total energy available from the disintegration of these rare and unstable elements is wholly trivial in comparison with that available from bottled and direct sunlight.

DAVIS: You mean then coal and oil and water and wind power and the power stored up in growing plants are all just atomic energy sent down to us in the form of sunlight and heat?

MILLIKAN: That's right, Mr. Davis, and so long as our supplies of gas, oil, and coal are not exhausted, these three forms of bottled sunlight are by far the cheapest sources of atomic energy available to us.

DAVIS: Are these fuels that we get out of the ground really atomic energy?

MILLIKAN: Yes, they are, because they are the captured sunlight of past ages and the light and heat of the sun and the other stars is due to atom-building processes, rather than to atom-disintegrating processes such as was released in the atom bomb. In the sun and stars at the very high temperatures such as exist in the interior of the sun, estimated at about 25,000,000 degrees centigrade, part of the mass of hydrogen, about one per cent of it, is converted into radiant energy — that is, into radiant heat and light. It is real atomic energy. So you see that atomic energy is really nothing new.

DAVIS: Will we ever be able to utilize here on earth this process of the release of atomic energy due to the building up of the heavier elements out of hydrogen?

MILLIKAN: In all probability this process is forever unattainable on earth or on any cold bodies. These reactions of building up the heavier elements out of hydrogen can take place only in furnaces such as exist in the sun and stars where there are temperatures of millions of degrees and pressures of millions of pounds per square inch. Yet this is practically the sole source of all the energy which the earth has received and which man has had at his disposal in times past. To it has been due all life on earth and every organized activity that differentiates the earth from the burned-out celestial cinders like the moon and some of the planets. For billions of years the sun has been shooting down to us in practically unlimited quantities this kind of atomic energy released by the building up out of the lightest element hydrogen the other elements.

DAVIS: Can you tell us how much energy pours down on the earth in the form of sunlight and sun heat?

MILLIKAN: Every square mile — that's 640 acres — of the United States receives from the sun during a growing season the heat equivalent of 172,800 tons of coal, worth, at six dollars a ton, over a million dollars per season.

DAVIS: And all this is really atomic energy. Why don't we make more use of this flow of solar atomic energy, Dr. Millikan?

MILLIKAN: We do make limited use of it when we install a windmill or develop a hydroelectric power plant or a solar heater. Also when, as has been done in a few places, corn or other crops are grown for the sake of the liquid fuel values to be obtained from them, we are using the power of the sun. But the stored sunlight of by-gone ages is here in such abundance and such cheapness in the form of oil fields and coal beds that the great bulk of our power will continue to come from such sources simply because no other source of power can compete with it in price. We should not worry about power for our children's children and their children, because, aside from its difference in cost, there need be little occasion to fear that they will lack necessary power to run the civilizations of the future.

DAVIS: Is there a chance that the other elements light in weight will become a power source in the way in which uranium now is?

MILLIKAN: No. What we are talking about here is what we call packing fraction energy, such as is released by a few heavy, unstable atoms like uranium which release energy by disintegrating into stabler ones. There is no available energy left in any of the lighter elements that are most abundant. They are abundant for the reason that they are stable. The atoms found on earth have had billions of years to respond to the universal tendency to settle down into their most stable states. Only hydrogen, which is thought to constitute 90 per cent of the universe, constitutes the great source of atomic energy through the process of building up from itself in the stars all the other atoms. But only a very few rare elements, at the heavy end of the list of chemical elements, are capable of yielding atomic energy on earth in the process of disintegration. They are easily exhausted, and therefore they will be increasingly costly. We should conserve them rather than spend them recklessly.

DAVIS: As I understand it, the reason that uranium, thorium, and possibly some other of the heavier elements are useful for atomic energy purposes is that a very small amount of their mass is converted into energy when they break down and transmute themselves into other more plentiful elements.

MILLIKAN: That's what happens in the atomic bomb. It's hard for us to realize just how scarce on earth that kind of atomic energy material really is. Uranium is not quite as rare as gold, but it is exceedingly rare. Suppose that we had no coal or sunlight and were forced to burn up our gold to get our heat and power. It wouldn't last long and you can imagine how the price of gold would skyrocket under the pressure of everyone to get some of it or freeze to death.

DAVIS: Just what are the most abundant elements in the earth's crust, Dr. Millikan?

MILLIKAN: Oxygen is by far the most plentiful element on earth. It accounts for nearly half of the earth's crust. Oxygen, silicon, aluminum, and iron together constitute 97.4 per cent of the earth's crust. Add calcium, sodium, potassium, magnesium, titanium, and manganese to these four elements, and these ten alone amount to 99 per cent of the earth's crust. You see, that doesn't leave much for the other elements. And so far as getting atomic energy from the fission or disintegration of any of them is concerned, the packing fraction curve shows very graphically how much available energy is left in each one of these elements. And as to the rarity of all heavy elements that could possibly be fissionable is concerned, the following is illuminating. Barium constitutes less than one part in a thousand of the earth's crust, and all the elements heavier than it — there are three dozen of them — together have an abundance less than that of barium alone. Uranium has only one-eightieth the abundance of barium. It has an abundance of six parts in a million in the earth's crust. So you see, atomic energy material is a very scarce article.

DAVIS: You began searching the world over for uranium ores for experimental purposes along about 1900, didn't you, Dr. Millikan?

MILLIKAN: After the discovery of radium, uranium ores which contained radium became very important. For the first ten or twelve years after radium was discovered in 1898, the pitchblend ores from the Joachimsthal mines in Austria which is now in Czechoslovakia supplied the world's demand. Then the then Austrian government put an embargo on export of this ore from these mines, the natural inference being that they were being pretty well worked out and Austria wanted to save a valuable resource. This led to the development of the carnotite deposits in Southwestern Colorado and Southeastern Utah where the yellow oxide of uranium has crystalized out on grains of sand. While these Colorado carnotites average less than one per cent uranium, compared with the Joachimsthal pitchblend a much richer ore, because of American skill in extraction, the Colorado carnotites supplied commercial radium of the world until the discovery of the Belgium Congo deposits which occasionally run up to 15 per cent uranium metal. The other great discovery of uranium was at Big Bear Lake in Canada.

DAVIS: Actually then, Dr. Millikan, there are only two places in the world from which uranium ores have been commercially obtainable in appreciable quantities during the last 30 years.

MILLIKAN: That's right. The Belgium Congo and Canada. Add to that the earlier finds in Joachimsthal and Colorado, and you have all that I know of. One can never tell, of course, when there will be another discovery of important uranium ore, but so far as we know, none has yet occurred. In any event, uranium will continue to be a very scarce element. It should not be used for any major fuel or power purpose.

DAVIS: What about thorium which we are told can be converted into uranium 233 which is a fissionable element, capable of yielding atomic energy?

MILLIKAN: The only way in which thorium can be used so far as I know is to process it in an atomic pile along with uranium. So that doesn't alter the situation very much.

DAVIS: What about the possibility of a new kind of atomic energy reaction through the use of mesotrons since they are now artificially created in the cyclotron?

MILLIKAN: So far as I am aware, there is no new source of energy in this reaction. I have as yet seen no claim that the reaction releases more energy than is supplied by the cyclotron to bring it about.

DAVIS: To prevent mankind from annihilation or at least his civilization from being badly disrupted, as well as to save precious uranium supplies, don't you think there's more reason than ever to have international control of atomic energy?

MILLIKAN: The failure to agree upon atomic energy controls within the framework of the United Nations may be one of the greatest failures of all times. No one wants another war, particularly an atomic war, and we must strive to prevent such a war at all costs. It's very late, but it's never too late to do everything we can to bring about a useful, creative and peaceful utilization of science for the benefit of mankind.

Dr. Millikan's classic book "Electrons (+ and −), Protons, Photons, Neutrons, Mesotrons, and Cosmic Rays" (Rev. ed. 1947) (University of Chicago Press) gives details of research and conclusions upon uranium, atomic energy and many other related subjects.

Cesium Vapor in Rectifier Tube

A NEW HIGHLY-EFFICIENT rectifier tube to change alternating electric current to direct current contains the vapor of cesium metal and has its cathode surface of cesium coated on nickel, General Electric reveals.

It has long life, and gives better than 98% efficiency, compared with 94% in some of the rectifiers now in common use, according to Dr. Albert W. Hull, under whom it was developed in collaboration with E. E. Burger and R. E. Turrentine of GE research laboratory.

The emission of electrons from the cesium, coated on the nickel surface, even at relatively low temperature, is one of the most copious known, Dr. Hull states. There is no appreciable evaporation of the nickel, and the coating of cesium is continually renewed from the vapor in the tube.

Cesium is a silver-white metallic element belonging to the potassium family. It gives up one electron more readily than any other element, hence its use as the light-sensitive film in photoelectric cells.

Foods dehydrated by the high-vacuum method used on penicillin and blood plasma has better flavor, color and vitamin content than by conventional dehydration methods, it is reported.

Lactic acid, widely used in industry, can be made cheaply by a new process from sulphite liquor, a pulp mill waste.

Properties of First Actinide Element Sought to Establish Basis of Theory

Actinium By Transmutation

➤ BELIEF THAT actinium is a third-group element, somewhat similar to aluminum in chemical behavior, although much heavier, is being tested in a new series of experiments. These were reported to the Chicago meeting of the American Chemical Society by Dr. French Hagemann of the Argonne National Laboratory in that city.

Actinium was one of the first radioactive elements to be discovered, nearly 50 years ago, but it is still one of the least known. It occurs in nature in small amounts, and was discovered in 1899 by Andre Debierne in working over some of Mme. Curie's pitchblende residues. But Dr. Hagemann at the present time prefers the method of transmutation to that of separation, and made his sample of actinium out of radium by irradiation.

Chemists who are working with the newly-made heavy elements beyond uranium are very much interested in learning more about actinium. They are quite strongly committed to the theory that elements heavier than radium, beginning with actinium, belong to a series, as yet only half discovered, which duplicates in most of its properties the series of rare earths introduced by lanthanum. Yet in setting up this hypothesis, they have to rely on the probable nature of an element about which almost nothing is known.

At the time of Debierne's discovery, chemical techniques were based on work with very much larger quantities of material than are used in the newer methods today. The men who designed the full-scale plutonium plant for the atomic bomb worked by stretching the dimensions upward from laboratory quantities too small to be seen.

Therefore it was sufficient for the Argonne Laboratory group to take one gram of radium and transmute a part of it to get three-quarters of a milligram of actinium, enough for a whole series of actinium compounds including halogen compounds, a sulfide and a phosphate. They find that, like other Group III elements, actinium is precipitated by ammonia as a gelatinous mass.

Actinium 227, the only long-lived isotope of the element, occurs in nature and is characterized by beta-emission with a small amount of alpha emission. Its chemical properties are so similar to those of lanthanum that they cannot be separated by ordinary methods. In two extant samples prepared by Mme. Curie, when actinium was first discovered, the radioactive element was carried by lanthanum and each sample contains only about one per cent actinium.

The present experimenters, therefore, being anxious to get the pure element uncontaminated by others with similar properties, chose to make their sample by transmutation from a different element. Actinium can be obtained as a decay product of protoactinium, but this is also an extremely

rare substance in nature, and its colloidal chemical properties are reported by Dr. Seaborg to be "exasperating." The Argonne Laboratories group, instead, made their actinium by irradiating radium 227 in the atomic pile.

With a supply of pure actinium and the method for making it now available, research men will go on to study the spectra given off by the element under various conditions, and the properties of the characteristic salts, and thus determine the electronic configuration of the actinium atom.

The Discovery of Actinium

A Classic of Chemistry

SUR UNE NOUVELLE MAATIÉRE RADIOACTIVE. *Note de M. A. Debierne, présentée par M. J. Violle.*[1] *Comptes Rendus, t. 129, 1899. (Translated for Chemistry by Helen M. Davis.)*

➤ M. AND MME. CURIE have shown that the emission of rays found in pitchblende proves to be not solely from the uranium contained in it, they have discovered the presence of two new radiant elements, polonium and radium, much more active than uranium.

Polonium acts like an element very much like bismuth, accompanying it in all its chemical reactions, but from which it may be separated slowly by repeated fractionations. Radium has all the chemical reactions of barium and it is also only by repeated fractionation that it is possible to observe a separation.

The individuality of these new elements, at first shown solely by their radio-activity, has been confirmed, for one of them, by observation of a distinct spectrum, made by M. Demarçay with radium prepared by M. and Mme. Curie. It seems therefore that the property of emitting such radiations can serve to discover and to characterize such chemical elements.

[1] Work done at the laboratory of chemistry and physics at the Sorbonne.

Upon the advice of M. and Mme. Curie, I investigated whether there were any other radiant ingredients in pitchblende, and my researches have been carried out chiefly upon those substances whose acid solutions are not precipitated by hydrogen sulfide, but are completely precipitated by ammonia or ammonium sulfhydrate.

The material which I used came from a plant for the refining of uranium minerals and was therefore almost completely free from uranium. The quantity of radiant products contained in this material appeared to be extremely slight, a first task consisted of organizing the treatment of a very great quantity of material, certainly many kilograms, and eliminating as completely as possible the radiant materials already known (polonium and radium).

The greater part of the product precipitated by ammonia was composed of oxides of iron and aluminum; but, besides these substances, I recognized the presence of a large number of others which were present in very small proportions. Thus I have been able to separate small quantities of zinc, manganese, chromium, vanadium, uranium, titanium, niobium, and tantalum; the rare earths were also

represented, and I have been able to determine lanthanum, didymium, cerium and yttrium.

The radio-activity, which existed in a slight degree in the crude mass of the group precipitable by ammonia, became concentrated at certain points according to the separations which were made.

I have thus ascertained that the portion containing titanium and its analogues shows the radio-activity to a very intense degree, and after a rather complicated treatment, the nature of which I shall come back to later, I have obtained a substance whose solutions show the principal analytical properties of titanium, but which emit extremely active rays.

The radio-activity of one fraction of this material has been determined roughly to be a *hundred thousand* times as great as that of uranium. Moreover, this material has chemical properties entirely different from those of radium and of polonium.

The radiations given off by this material are entirely comparable to those which have already been observed by M. and Mme. Curie for polonium and radium.

They give off a gas capable of discharging electrified bodies, they excite phosphorescence in barium platinocyanide and they leave an image on a photographic plate.

The new material nevertheless is different from radium in that it is not spontaneously luminescent: M. and Mme. Curie have in fact found that the compounds of radium, in the dark, emit a perfectly distinct glow.

I reserve the privilege of reporting further, soon, upon this radio-active material.

New Mineral Deposits

➤ AMERICA'S MINERALS, of the kinds we have, will last longer than some predict, due to new discoveries by government and other agencies, the Secretary of the Interior, J. A. Krug, indicates in his annual report. There are, of course, essential minerals not found within the United States.

Old-time prospecting for minerals is out. Surface deposits, most of them, have been found and many exhausted. Below the surface, according to Dr. W. E. Wrather, director of the Geological Survey, lie enormous volumes of rock which contain concentrations of useful minerals which in many instances are as abundant as those closer to the surface.

Modern scientific explorations, carried out by geologists, geophysicists and geochemists, must be used to discover this hidden wealth. The Survey, he states, has developed highly refined techniques in its program of exploration and appraisal of deeply buried ores. They are already in use.

Additions to the nation's mineral reserves are reported by the U. S. Bureau of Mines. They include copper, iron, and lead-zinc ores, not in large amounts but sufficient to produce commercial metals. One deposit contains 21,000,000 tons of black sand composed of 54% titanium, 15% zircon, 14% staurolite, and other minerals. This is important with titanium oxide now becoming a principal pigment in white paints and the wider uses of zirconium in electrical and chemical porcelain and in alloys.

Radioactive Tracers Allow Researches Once Impractical

Tag!

Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.

A NEW PHASE in use of radioactive tracers for industrial research is indicated by the recent completion of the largest tracer experiment ever conducted, and probably the first using full-scale industrial process equipment. Sponsored by the Republic Steel Corporation, the experiment was conducted in their Cleveland plant by Arthur D. Little, Inc. For over a decade, biologists and medical workers have used tracers. Although over 75 per cent are still used in biological work, use of these "tagged" atoms in industry has increased greatly in the year and a half since the Atomic Energy Commission has made many new kinds available at lower prices. Now that industrial workers are learning how and where to use the tracers, they expect to solve many knotty research and control problems.

The recent study was one step in a program for keeping undesirable sulfur out of steel, and is typical of the instances where tracers are especially useful. Sulfur enters steel in many ways — with the coke derived from coal, or with ore, limestone, scrap, or fuel oil. Some of it leaves the system in slag or flue gases, but some reaches the finished steel. In the finished steel, one cannot tell which raw material supplied the sulfur, except by tedious and inconclusive statistical correlation of sulfur content of the raw materials with that of the steel. This method showed coal to be the chief culprit, but steelmakers still were not certain which of the chemical forms of sulfur in the coal got through to the coke and then entered the blast furnace.

There are two important forms of sulfur in coal, pyritic and organic. Since the forms change in the coke oven, there is no chemical method for learning whether the surviving sulfur in the coke comes from the original pyritic or organic sulfur, or whether low-pyritic coal or low-organic coal is the better raw material. If one of the forms is tagged with radioactive atoms, however, its travels can be followed very precisely with radioactivity counters. In the present work, a small amount of artificial pyrites was made from radioactive sulfur and thoroughly mixed with twelve tons of coal, the normal charge of a coke oven. The proportion of the coke's sulfur which had come from the pyrites was then found by measuring the radioactivity of the sulfur. This proportion was about the same as in the original coal, indicating that both forms are carried over to the coke equally, and that there is no advantage in buying coal with a low pyritic-sulfur content. More tests are planned to trace sulfur in other materials and chemical combinations through the steel-making process.

Radioactive tracers have also been used in such jobs as determining the concentration of toxic fumes in industrial plants, measuring the lubricant applied to textile fibers in amounts so

small that ordinary measurements fail, determining the minute amount of metal transferred when a shaft rotates in a bearing, and studying the mechanism by which plants produce food from carbon dioxide, water, and other nutrients by photosynthesis.

Use of tracers to control industrial processes is being considered. As an example, radioactive phosphorus added to a Bessemer steel furnace would show when the last impurity, nearly always phosphorus, had been removed from the steel. Automatic controls could also be connected electrically to radioactivity-measuring instruments to turn down and shut off the Bessemer at the right time.

Research with tracers is characterized by directness and simplicity. Often, as in the coke-oven work, the experiment can be run in full-scale equipment. This is important, for there is sometimes serious doubt whether a conclusion reached in the laboratory will hold in the plant itself. Radioactive materials from the atomic pile are not expensive. The sulfur for this study cost only about $50, compared with thousands of dollars prewar, when radioactive materials were made in the cyclotron. Better measuring instruments are now available, and more technologists are familiar with radioactivity. Since research using AEC tracers is made public, this familiarity is expected to grow.

On the other hand, not all elements have radioactive forms suitable for tracer uses. For example, radioactive oxygen loses about half its radioactivity every two minutes. Many important radioactive elements are not available from the atomic pile, and must still be synthesized in a cyclotron at much greater cost. The AEC restricts purchase and use of radioactive elements to protect the experimenter and the general public against misuse. The Commission considers the applicant's professional qualifications, the instruments available for safeguarding health, and the intended use. The requirements of the AEC reflect the danger possible with radioactive materials. A properly planned experiment should involve precautions such as the use of a minimum amount of active material, appropriate shielding, avoidance of inhalation and ingestion of the material, and safe disposal of all waste containing active materials. In the coke experiment, special precautions were taken, such as devising techniques to allow use of only small amounts of radioactive materials.

The potentialities of the tracer method of research so far outweigh its restrictions that its future is considered brilliant. Research directors are reconsidering many research projects, even those previously abandoned as impractical, to see if this new tool can be used.

Oxygen Aids Steel Manufacture

➤ Use of oxygen on a large scale may help solve the steel shortage. Prof. Barnett F. Dodge of Yale has told the American Chemical Society that methods of manufacturing oxygen worked out in pre-war Germany to compensate for lack of raw materials are about ready to be applied to American industry. Economies in producing heat needed in steel manufacture are promised by experiments at Yale.

Monoxide on Distant Planets?

➤ IF LIFE on some planets is impossible because of the presence of poisonous gas, astronomers will soon know about it. A search for carbon monoxide in the atmosphere of Mars, Venus, Jupiter and other planets is being conducted by Dr. G. P. Kuiper at the McDonald Observatory of the University of Texas.

Only one of the satellites of Jupiter may have had an atmosphere at one time. Its reddish color is in striking contrast to the other three satellites. To date no detectable atmosphere has been found on the distant planet Pluto or on Neptune's satellite, Triton.

Magnetic Oil in New Fluid Clutch

➤ MAGNETIC OIL is the key to a new automobile fluid clutch revealed by the National Bureau of Standards. It development is a discovery of number one importance. The oil contains millions of tiny particles of iron dust or other magnetic material. The car electric system magnetizes them as needed.

This new magnetic fluid clutch is very simple. It has three elements only, a driving shaft with a plate at its end, a driven shaft and plate, and the iron-saturated oil between. When a magnetic field is established between the two parallel plates, the magnetic particles form chains which bind the two plates together as tightly as if they were held by strong spring clamps.

Operation of the clutch is described as extremely smooth and without "chatter." The locking force is practically constant, and the bond between the two plates is a function of the gradual increase of the magnetic field, which is electrically controlled. The relation between the amount of magnetization and the bond between the plates is independent of speed. There is no point at which the clutch suddenly tightens to produce a jerk. Slippage is completely eliminated.

This magnetic oil may be used in brakes as well as in clutches, but according to its inventor, Jacob Rabinow of the Bureau staff, it has other applications which may be even more important. These are in servo-mechanisms, instruments to translate electronic "information" into appropriate action in purely mechanical equipment. Such devices are used for power steering of large trucks, tanks, steamships and airplanes. They are also used in printing presses, power machinery, for the control of radar antennas, gun direction control, and in high-speed electronic computers.

Since the amounts of electric power required to control the magnetic fluid clutch are small, it is a simple matter to interlock the electrical circuits with the speed, throttle setting and power demands. It has been found by experiment that the nature of the oil used has relatively little bearing on performance. Hence silicone liquids may be employed with excellent results, enabling the clutch to operate at very low and very high temperatures.

Hardest Beta and Gamma Rays Given Off by Iodine Isotope

Radioactive Iodine Measured

➤ THE MOST penetrating rays produced by any of the radioactive isotopes resulting from fission of uranium are given off by an isotope known as 86-second iodine, whose properties were described by Charles W. Stanley and Seymour Katcoff of the University of California Los Alamos Scientific Laboratory, Los Alamos, N.M., at the recent meeting of the American Chemical Society at Chicago.

At least 160 radioactive isotopes of 35 different chemical elements are produced when uranium undergoes nuclear fission. In general, the isotopes whose half-lives are only a few minutes or seconds cannot be isolated before they disappear by decay. The chemical nature of iodine, however, permits a very rapid and clean separation from all the other fission elements. In the work described, this separation took about four minutes.

Strassmann and Hahn in 1940 discovered a short-lived iodine fission product whose half-life they reported as 108 ± 24 seconds. Now the half-life has been redetermined more accurately as 86 ± 1 seconds. This was facilitated by measuring the radiation which passed through a 2 millimeter thick aluminum plate. The aluminum absorbed much of the beta-radiation coming from other iodine fission products, but the extremely hard beta-rays of 86 second iodine were absorbed only slightly.

In fact, it was found that an aluminum thickness of 12.6 millimeters is required to completely absorb the 86 second iodine beta-rays; thus their maximum energy must be 6.54 million electron volts. This is the highest beta-ray energy yet recorded for any known fission product. The gamma rays were also found to be harder than those of any other identified fission isotope. A thickness of 17.3 millimeters of lead was needed to reduce the gamma intensity to one half, thus establishing the energy as 2.9 million electron volts.

The mass number of the 86 second iodine was shown to be most probably 136. Mass numbers 137, 138, and 139 were ruled out because it was shown that the 86 second iodine does not decay to the well known xenon or cesium isotopes of these masses. Assignment to a mass below 136 is very improbable because other isotopes of iodine are located there with the fission yield expected from the mass-yield curve.

. It was found that 2.3 out of every 100 fissions of uranium-235 result in 86 second iodine. For plutonium-239 and uranium–233, the corresponding numbers are 1.1 and 1.2. All of these values are low compared to the 6 per cent value expected from the yield versus mass curves. One possible explanation may be the existence of an independent isomer of 86-second iodine so that the remainder of the yield could be along the isomer.

These experiments would not have detected an isomer whose half-life is

less than 30 seconds. It might also be that most of the missing portion of the chain yield is in the production of the xenon daughter as a primary fission product. By successive extractions of iodine from neutron-irradiated uranyl nitrate solution, it was shown that the observed 86-second iodine does not grow from a tellurium parent whose half-life is greater than 20 seconds.

At a Safe Distance

➤ ADAPTING *the useful hooks of the amputees to the problem of handling radioactive chemicals at a safe distance, John Payne of General Electric demonstrates how his mechanical hands will operate on the other side of a safe shield at the new Knolls Atomic Laboratory which G-E will operate for the Atomic Energy Commission.*

Spontaneous Combustion
With Lead Tartrate

A Cascade of Fire

by JOSEPH H. KRAUS

➤ A BLACK POWDER which will burst into flame the moment it comes in contact with air, producing a spectacular flash and a large volume of smoke, can be made readily from lead tartrate. Only the simplest equipment is needed.

Use a pyrex test tube. Quarter fill it with powdered lead tartrate. Place the tube in a nearly horizontal position and, by shaking, spread the material as evenly as you can along the bore of the tube. Because of a tendency of the powder to puff out of the tube during the heating process, fit the end of the tube with a single hole stopper and a one-or two-inch length of glass delivery tubing.

Heat the lead tartrate evenly along the length of the pyrex tube until the chemical takes on the appearance of a black powder and fumes stop coming off. If the powder puffs up and moves toward the delivery tube, shake it away from the inner opening. You don't want to clog this outlet. Avoid inhaling the fumes. It is better to do the heating in a fume hood if you have one, or near an open window.

When the material has taken on a carbon-like appearance and no gas comes off any more, heating is discontinued. The delivery tube and single holed stopper must now be removed while the tube still is hot, and the tube corked tightly.

Work with small volumes. If a greater quantity of powder is needed for the demonstration, it is recommended that another quarter tubeful be prepared.

Spontaneous Combustion

After the tube has cooled to room temperature, uncork and spill about a teaspoonful of the black powder on an asbestos plate. You will see that the powder starts to burn along the edges first, with small licks of flame. Gently blow at the powder and the flames will be fanned to a greater height, but they still will not look too promising.

Now slowly tip the asbestos sheet away from you, so that your audience can see what takes place. As the powder falls, a sheet of fire will cascade toward the floor, accompanied by considerable smoke. It makes a striking demonstration.

Do not use more than a teaspoonful of powder at first for each demonstration. Larger quantities may perhaps be used later, after you get the knack of the experiment. It maintains its potency for spontaneous combustion for months on end if properly corked. See to it that none of the powder is left lying around the lab.

Probably no experiment can beat this one for sheer spectacle, ease of preparation, and minimum of laboratory equipment. It could well be included in any chemical magic show.

Turkey now has its first window-glass manufacturing plant.

Methyl Orange

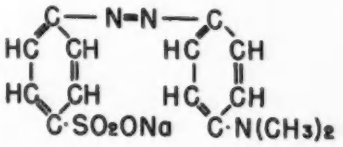
by Burton L. Hawk

▶ The technical name for methyl orange is sodium p-dimethylaminoazobenzene-sulfonate. (Hereafter, we will refer to it as "methyl orange"). It is formed by the diazotisation of the amino group of sulfanilic acid and the coupling of the resultant products with dimethylaniline hydrochloride. But don't get discouraged; it really isn't as bad as it sounds. We shall proceed slowly, step by step.

First, thoroughly dissolve one gram of sodium carbonate in 25 cc. of water using a 100 or 150 ml. size beaker. Now add 3 grams of sulfanilic acid. When the resultant effervescence ceases, warm the mixture until all solids are dissolved; then allow to cool.

In another container, dissolve one gram of sodium nitrite in 5 cc. of water. Add this to the sulfanilic acid solution. Stir and cool the liquid by placing the beaker in a mixture of crushed ice, salt and water. Bring to a temperature of 5 degrees. Add to this, drop by drop, a solution of 4 cc. concentrated hydrochloric acid in 8 cc. of water. Stir after each addition and do not allow the temperature to rise above 10 degrees. You may accomplish this conveniently by using a thermometer to stir the liquid.

The above procedure is known as *diazotization*, which simply means the formation of diazonium salts. It seems that when nitrous acid acts upon the salts of aromatic primary amines, compounds with properties



characteristic of ionic salts are formed. They have been termed "diazonium" salts because of their analogy to ammonium compounds. They are usually unstable and most of them are explosive in the dry state. For that reason, we are happy to oblige and keep them in aqueous surroundings. Because of their great activity, they find valuable use as intermediates in the preparation of many synthetic compounds and dyes.

In our experiment, the compound formed is benzenediazonium sulfonate. It is only sparingly soluble in water and will separate out as hydrochloric acid is added. After the acid has been added, let the solution stand for two or three minutes—no longer.

Mix together 2 cc. of dimethylaniline, 2 cc. of hydrochloric acid and 5 cc. of water. Cool and add to the cold diazonium salt solution. Stir rapidly and let stand for about five minutes. A deep red color should be formed. Upon adding a solution of sodium hydroxide (3 grams of NaOH in 10 cc. of water), methyl orange will separate in fine orange crystals. Heat until a uniform orange color is formed. Add about 5 grams of salt and allow to cool. This will cause more

complete precipitation of the methyl orange. The solution is now filtered, and the precipitate purified by dissolving in hot water and recrystallizing.

Coupling

This latter portion of our experiment is known as *coupling*, which is the reaction of a diazonium salt with an amine, in this case, dimethylaniline. In other words, coupling occurs between benezenediazonium sulfonate and dimethylaniline with the resultant formation of *p*-dimethylaminoazobenzene-*p* sulfonic acid. The addition of sodium hydroxide converts the acid into the sodium salt, methyl orange.

If your solution turns dark green instead of orange, it is probably due to the formation of *p*-nitrosodimethylaniline. This compound is formed when an excess of nitrous acid is used and is insoluble in water. However, when warmed with sodium hydroxide it is converted into the soluble *p*-nitrosophenol. Thus you may still obtain methyl orange by allowing the solution to cool and filtering off the precipitate. It will be necessary to repeat the process several times. The precipitate is then purified as before.

Methyl orange is used as an indicator. Dissolve a small amount of it in warm water. Add a small quantity of hydrochloric acid and a lovely red color appears. With alkali solutions, the indicator turns yellow.

Although it forms a beautiful orange color, methyl orange is not used as a dye because of its sensitivity to acids and alkalies.

Coal Key To Continued Prosperity

➤ Not atomic power, but old-fashioned coal—dirty, smoky soft coal—is the key to America's continued prosperity and power.

Prof. S. W. Hockett of Iowa Wesleyan College has determined that, of power sources now in sight, American coal reserves constitute 98.8 per cent, with natural gas, oil shale and petroleum splitting the small remainder among them. Coal reserves of the nation total up to 2,556 billion tons, while the reserves of the other three fuels will provide the energy equivalent of only a little more than 30 billion tons of coal. It has been estimated that America's known coal reserves can meet the fuel needs of the next 2,000 years.

Iowa coal is the Cinderella of American soft coals. By carbonizing it at relatively low temperatures — around 500 degrees Centigrade—Prof. Hockett was able to produce good, easily cleaned fuel gas, a high-grade, easily ignited coke, and an abundance of coal tar products much in demand by industry.

Small units for low-temperature carbonation of soft coal have recently been developed. It appears feasible to move them about on trucks so that they can operate at the pit-head or even down in the mine itself. Gas thus produced can be either piped to nearby cities or bottled and sold to rural users of that type of fuel. Shipping costs should be much lower on the more compact solid and tarry products of the new technique.

Invisible Odorless Gases Detected by New Device

Positive Ion Nose For Gases

➤ A LABORATORY device, described as having a sense of smell but which does not really function in the same manner as the human nose, detects certain classes of invisible vapors and air-borne particles including some which have no odors.

The instrument was described to the Institute of Radio Engineers by William C. White of General Electric, and also described by J. S. Hickey of Schenectady on the General Electric W.G.Y. Science Forum.

The basic phenomenon used in this detector is the positive ion emission from a hot platinum surface operating in air. Electrons are the basic particles of electricity. Positive ions are atoms which have lost one or more electrons, they explained.

The emission of positive ions from a surface can be greatly increased by certain vapors present in the air striking the electrode surface, it has been discovered recently. The chief requirement for these vapors is that they contain one of the halogens, fluorine, chlorine, bromine or iodine. The percentage increase in current is enormously greater than the percentage of halogen in the air.

We have taken this knowledge, both scientists said, and made a sensitive element comprising a red hot center electrode surrounded by a cylindrical outer element. Since this device uses positive ions instead of electrons, the inner hot electrode must be made positive in respect to the outer and is the anode of the tube. The entire electrode structure is made of platinum, which is one of the materials that can run red hot in the air without oxidizing.

To use this sensitive element as a leak detector, it is mounted in a casing. A small blower moves an air sample through a sampling tube and from there through the sensitive element. A pistol grip is added for convenient holding. The whole assembly looks like a "Buck Rogers" pistol.

The pistol, or detector, is connected by a cable to a control box which takes current from a 115-volt alternating current circuit, and supplies the sensitive element with low voltage for the heater and blower motor and direct current for the cathode. In addition it contains a simple amplifier to increase the signal from the sensitive element, and to give an audible response.

If a vessel suspected of having a leak is put under pressure with a gas containing a halogen there will be a concentration of the leaking gas near any leak that might exist. When the sampling tube is passed along the suspected surface, the presence of the escaping gas is evidenced by a change in tone of the signal from a loudspeaker.

Artificial eyes are now being made of acrylic plastics.

Shop Talk by Chemists
At Chicago Meeting

Current Chemical Research

➤ SOME OF THE newest achievements of chemistry, reported to the American Chemical Society meeting at Chicago were:

Sugar made from waste oak wood.

Sweeter molasses plus a sugar-cane by-product for soap production.

A new softener for some types of plastic from sour milk.

Cheaper alcohol for auto fuel.

Sugar can be made from oak wood waste, Dr. Elwin E. Harris of the Forest Products Laboratory, Madison, Wis., told the chemists. By treating it with a little sulfuric acid under steam pressure, it can be made to yield 45% sugar.

Sugar cane can be made to produce a by-product of use in synthetic soap making and the molasses will be sweeter as the result. R. J. Furse and Leon Godchaux II of New Orleans told of success in extracting the aconitic acid, which is also a softening agent for plastics and rubber.

Lactic acid, the tang of sour milk, can now change waste farm products into softeners for vinyl plastics products, a chemical team from the U. S. Department of Agriculture's Eastern Regional Research Laboratory, Philadelphia, reported. Dr. C. E. Rehberg, Marion B. Dixson and Philip E. Meiss explained in their report that the agricultural products otherwise wasted would replace chemicals made from oil, now in short supply.

A step toward cheaper use of alcohol for automobile fuel was reported by Dr. Donald F. Othmer of Brooklyn Polytechnic Institute, who told the chemists that the use of a new distillation process makes it just as cheap to produce absolute alcohol, 100% free from water, as the ordinary industrial alcohol which contains 5% water, interfering with its use as fuel.

Sunlight Paint

➤ SOON YOU'LL be painting your house with "invisible sunlight" thanks to pigments that soak up light you can't see and give off vivid color.

Chemical research, reported by Dr. C. E. Barnett of the New Jersey Zinc Co., Palmerton, Pa., has increased tenfold the luminescent qualities of paint pigments.

During the war major improvements were made in materials that glow in the dark, and now the fact that some of these have "daylight fluorescence" is being applied to signs, soap and paint.

Ultraviolet light is absorbed on striking the materials and then emitted as visible color. The addition of this color to the normal reflection gives a more brilliant hue than can be obtained by reflection alone.

Synthetic Varnish

➤ THE WORLD'S first completely synthetic varnish, made from petroleum, promises to add to the world's food supplies by replacing paints and varnishes now made from edible vegetable oils.

The new type varnish prepared from a new petroleum chemical, glycerol allyl ether, was announced to the American Chemical Society by chemists from the Shell Development Company, Emeryville, Calif.

Insoluble films, hard to hurt with chemicals and resistant to scratching, are formed by the new varnish. It is made in several chemical steps from propylene gas, which is abundantly available from cracking oil.

Manufacturers are expected to apply the new varnish where they now use resins made from a combination of synthetic materials and scarce natural drying oils.

Linseed oil, soybean oil and cottonseed oil, which can be used as food, have been used as major ingredients up to now of so-called synthetic paints and varnishes. The new varnish is one of several attempts to replace some of the scarce vegetable oils with synthetic products made from more available non-food materials, such as crude oil.

H. Dannenberg, T. F. Bradley and T. W. Evans were the Shell chemists who did the research.

Whisky of the Future

➤ WHISKY of the future can be made from wood, instead of being merely aged in the wood. Science is ready to substitute sawdust for grain in ethyl alcohol manufacture and save huge quantities of wheat, corn and other grain for feeding a hungry world. Only federal regulations prevent this from happening now.

Dr. Robert S. Aries of the Brooklyn Polytechnic Institute told the American Chemical Society meeting that a $3,000,000 alcohol plant already built could produce 10,000,000 gallons or enough to make over 25,000,000 gallons of whisky. A ton of sawdust now wasted can yield about 50 gallons of drinkable alcohol.

Natural gas and petroleum refinery wastes can also be made into alcohol as good as grain alcohol, Dr. Aries claimed. The cost of alcohol from wood waste is a third of that from grain and the synthetic alcohol from oil and gas costs even less.

The drinker might not be able to tell the difference, Dr. Aries said. Slogans such as "Made from wood, aged in the wood" might win public approval for the new kind of whisky.

If the regulations of the Treasury Department controlling liquor manufacture were changed, the labels on the bottles might read "sawdust neutral spirits" and "petroleum neutral spirits" where they now read "grain neutral spirits."

The more than 10,000,000 tons of sawdust wasted annually could supply more than three times the demand for whisky. Every ton turned into alcohol would replace 20 bushels of corn or wheat.

Aluminum Soap Thickens Gas

➤ THE WAR-TIME secret of what makes gasoline thicken into a jelly for use as a liquid incendiary in flame-throwers or fire bombs has been revealed.

It is a soap made with aluminum instead of the usual chemicals in ordinary soap, Dr. Walter H. C. Rueggeberg of the Army Chemical Center, Edgewood, Md., told the American Chemical Society.

Existence of jellied or thickened gasoline was known during the war, particularly in the Pacific and especially to the Japs in dug-outs, who learn-

ed the hard, flaming-hot way. But it was not told just how the scientists thickened the fuel and made it so jelly-like that it stuck to things it was thrown against.

Aluminum soap thickeners consist of three kinds of chemicals: 1. an aluminum salt of the soap-forming saturated, fatty acids. 2. an unsaturated soap-forming fatty acid. 3. naphthenic acid. These are used separately or as a mixture. Napalm, one of the most successful of the incendiary gels, is an aluminum soap of an oleic, naphthenic and coconut fatty acid mixture.

These aluminum soaps have interesting and unusual properties that no other similar group of compounds possess. They become thick and viscous when shaken. They make the gasoline "set" when mixed with it. Chemists call this property "thixotropic."

Under cloak of post-war secrecy, it is known that experiments are being pushed vigorously to make even thicker and more solid gasoline so that fuel can be stored and handled somewhat like a solid instead of a liquid. This present military research is probably based on the war-time successes, although it was not discussed at the meeting.

Dr. Rueggeberg did make known that natural and synthetic rubbers as well as plastic resins such as the polyacrylates can be used as fuel thickeners. These produce jellies that are somewhat different from the soap-thickened fuels.

Soap-Thickened Oils

➤ LUBRICATING greases are soap-thickened oils. The soaps are manufactured from different metals and a variety of fats. These greases, upon being worked, as is the case when run in a bearing, tend to soften. However, upon discontinuing the rotation of the bearing, many greases return to nearly their original body.

It is desirable that we understand why this so-called "thixotropy" occurs and what lubricating greases possess this quality to the greatest degree. If greases stiffen to too great an extent, they cannot be pumped through delivery lines. Yet, if they become heavier outside the zone of working, they will act as a seal and prevent entrance of dirt.

Lubricating greases made from soaps of aluminum, barium, calcium, lithium, sodium, and strontium, in a study reported by C. J. Boner of the Battenfield Grease & Oil Corporation, Kansas City, were broken by shear in a grease worker. This consisted of a perforated disc repeatedly forced through the body of the lubricant. The consistency was then immediately determined by finding how far a cone of determined weight would penetrate a flat surface of the grease. Similar samples of worked grease were held and tested for consistency at stated intervals.

It was thus found that greases made from soaps of monovalent metals have the least return to consistency, while greases made with soaps of the metals of higher valence have the greatest tendency to harden after being sheared.

New Batteries Needed

➤ SERIOUSLY HANDICAPPED by lack of technical knowledge, science must find substitutes for the increasingly scarce basic materials for vitally needed electric batteries, Dr. Walter J.

Hamer of the National Bureau of Standards, Washington, D. C., told the meeting.

Today in civilian life new types of batteries are needed for electronic equipment, declared Dr. Hamer in his introductory remarks at a symposium on galvanic cells and batteries of the Society's Division of Physical and Inorganic Chemistry.

One of the outcomes of recent research has been the realization that there are serious gaps in our knowledge of the physical and inorganic chemistry of systems at extreme low and high temperatures, of the problems involved in the mechanism and construction of miniature cells with high potential energy, and that the usual battery materials are becoming scarce and that substitutes will be necessary and must be found.

At both high and low temperatures, he pointed out, there may be significant differences in cell behavior from that at normal temperatures.

There is ample evidence that such differences exist. These problems, as well as others, such as the structural reason for lead dioxide being the only known oxide that may be considered an electronic conductor and hence an excellent battery material, should appeal to the appetite of the theorist.

The renewed interest in reserve-type batteries or those activated at the time of use has broadened the approach to the subject of cells and enlightened the thinking in this field. The orthodox approach to battery problems may need to be abandoned. Batteries that are activated either mechanically, by water, by shock or by heat should store indefinitely without deterioration, but in operation are primary cells of short shelf life or duration. When dealing with batteries of this type, it is not necessary to think in terms of reversibility, shelf life or effects of chemical side reactions.

Four or five new types of batteries which show promise have been developed, including the so-called perchloric acid cell, the water-activated silver chloride cell, the shock-activated proximity fuse battery and the oxide-alkaline cells, while many more have been suggested, Dr. Hamer said.

Referring to war research, he stated that a large demand existed for new types of cells or batteries, which were needed for diverse purposes such as proximity fuses, artillery, pilot balloons, submarine torpedo propulsion, "night viewing" equipment, radar, bazookas, walkie-talkies and mines.

Batteries of high voltage and of various sizes were needed, he declared. The problems were attacked from many angles and various new tools were utilized for the purpose. Investigations were made of primary cells, accumulators, fuel cells, non-aqueous batteries and reserve type cells.

The problem of the low-temperature battery is largely a problem in physical chemistry. There is little information on electrolytes, metals, oxidizing agents and on battery operation rates at extreme low temperatures, such as are encountered in the stratosphere or the arctic regions. The problem of the high temperature battery for use in the tropics is mainly one of chemical reaction rates, such as drying, local action or corrosion.

Flavor Improver

➤ THE AMERICAN housewife can improve the taste of stews, hash and vegetables by adding a chemical which the Japanese introduced forty years ago, a session was told.

The chemical, monosodium glutamate, is a recent culinary development in the United States, but its use here has been mainly in manufactured food products and in industrial cooking operations, M. J. Blish, protein research supervisor of the International Minerals and Chemical Corporation's amino division, Rossford, Ohio, reported.

The American soldier found the chemical in his "K" ration dry soup, and more recently it has been packaged mainly for restaurant cooking, a use which probably will be expanded, he said.

Thus far, in this country, there has been no conspicuous attempt to make glutamate, as such, available for general household use, Mr. Blish asserted. Although approximately 6,000,000 pounds of it were produced in the United States last year, the average housewife is as yet uninformed as to its nature and potentialities.

The taste improvement is apparently caused by the chemical's intensification of natural flavors rather than by any flavor of its own, since it has little or none when properly applied to cooked foods.

Other familiar foods it improves are meat products, seafoods, chowders and gravies, according to Mr. Blish, who said that flavors of frozen or dehydrated vegetables particularly benefit from the chemical. In addition, vegetables made tasteless by long standing in steam tables are greatly improved by monosodium glutamate.

In some cases the chemical destroys undesirable tastes, Mr. Blish asserted, but he emphasized that in foods of poor quality it may intensify unpleasant flavors and it will not help conceal inferiority resulting from contamination.

Methionine in Alfalfa

➤ ALFALFA HAY is one of the most valuable roughages grown in the United States, according to Edwin T. Mertz and Allan F. Kingsley of Purdue University, speaking before a general meeting of the Division of Agricultural and Food Chemistry. It is used extensively in the ration of beef cattle, dairy cattle, and sheep.

Alfalfa is especially rich in proteins and minerals. The proteins of alfalfa are an important raw material for the production of meat protein in farm animals. A knowledge of the amino acid content of alfalfa should aid in the development of improved strains of alfalfa containing well-balanced protein for meat production.

Microbiological analysis of four genetically different strains of alfalfa for the ten essential amino acids showed that methionine was disproportionately low. Analysis of thirteen other strains of alfalfa for methionine confirmed this observation. The methionine content of the seventeen strains studied varied from twenty-two to sixty-six milligrams of methionine per gram of total nitrogen. The average value was forty-eight milligrams of methionine per gram of total nitrogen. This average value for methionine is approximately one-fourth of the value reported in the literature for meat protein. It may be concluded that

none of the strains of alfalfa examined to date have an adequate level of methionine.

Tall Oil Soap

➤ CHEMISTS have discovered that good soap can be produced at low cost from a forest material called tall oil, Dr. Foster Dee Snell and Irving Reich of Foster D. Snell Inc., New York, reported.

Describing recent research on this oil, a chemical by-product of the paper-making industry, the report said that the material became unusually important during the war, when shortages of fats and oils ordinarily used in soap manufacture led to the development of new and improved methods of recovering and processing tall oil.

Experiments have shown that soaps made with tall oil are efficient cleaning agents and are also economical, since refined tall oils sell at less than half the price of soap-making fats, and cost less than the rosin used in soaps.

For many years it has been common practice to add considerable amounts of rosin to laundry soaps. During the soap-making process, the rosin is converted to soap and acts as an extender.

Tall oil is a mixture of about equal amounts of fatty matter and rosin-like material. In the soap-making process, the tall oil is converted into rosin soaps and fatty soaps. The rosin soaps made from tall oil are comparable to ordinary rosin soap in detergent effect. The fatty soaps made from tall oil show the cleaning power and the sudsing power of many common vegetable-oil soaps.

Amino Acids for Plants

➤ PLANTS can utilize amino acids, the building blocks of protein, as their sole source of nitrogen, Bhanu P. Ghosh and R. H. Burris of the University of Wisconsin reported.

Tomato, tobacco, and red clover responded as well to the amino acids *DL*-glutamic acid or *L*-glutamic acid supplied in extensive greenhouse tests as they did to inorganic nitrates, principal source of nitrogen in commercial fertilizers, according to the report.

Other amino acids which gave good results were cystine, *L*-lysine, *L*-arginine, *DL*-aspartic acid, *L*-proline, or beta-alanine, the report said, noting that the plants were grown from disinfected seeds under sterile conditions.

The amino acids vary greatly in their ability to support the growth of plants, it was stated, and some are actually toxic.

Poor development was observed when the plants were fed on *L*-tyrosine, *DL*-tryptophan, or *DL*-serine, and in amino acid *L*-hydroxyproline the plants could not be grown at all.

Flame-Retardant Plastics

➤ SAFER SMALL PLANES are promised by recent research on flame-retardant coatings for aircraft fabrics.

Extensive fire and weather tests have been conducted on several experimental coatings, and in one experiment researchers succeeded in doubling the interval between contact with flame and destruction of coated fabric, according to a paper by Dr. Samuel G. Weissberg and Dr. Gordon M. Kline of the National Bureau of Standards, Washington, D.C., and Harvey L. Hansberry of the Civil Aeronautics Administration Experimental Station, Indianapolis.

Several formulations which showed up well in both the weathering tests

and the burning tests are suggested as a basis for further development.

The ultimate development of the desired coatings would chiefly benefit owners of small planes, since large commercial airliners are mainly built of metal with little or no fabric near their motors, while small craft are fabric-covered.

There are no inherently fire-retardant, film-forming materials which tauten airplane fabrics as effectively as cellulose derivatives, the authors state. The experimental work was undertaken to find a coating which could be applied over fabrics already treated with cellulose acetate butyrate dope, a less inflammable chemical than cellulose nitrate dope, widely used.

The flame tests showed it possible to increase the interval between contact with fire and destruction of the fabric from two seconds with cellulose nitrate dope and six seconds with cellulose acetate butyrate dope to twelve seconds with a fire-retardant coating over the latter dope.

Several film-forming chemicals were mixed with various pigments, resins and plasticizers in the hunt for an effective coating, and these formulations were tested for their suitability as fire-retardants and their durability in accelerated and natural weathering.

Laboratory and wind-tunnel tests simulating fire conditions in flight were made on doped fabric panels with and without the protective coatings, and the comparative times required to destroy the different panels noted. Temperature was also recorded to estimate the additional protection afforded by the coatings.

Current experimental work grew out of CAA tests conducted five years ago at the National Bureau of Standards which pointed to the inflammability of dope-tautened fabric as imperilling chances of controlling a plane with an engine ablaze.

Vanillin Research

➤ SUNTAN LOTIONS, cosmetics, food preservatives, and many other useful products can be made from wood wastes as the result of recent chemical research, two Wisconsin scientists told the society.

The new products are derivatives of vanillin, an extract of lignin, the principal solid ingredient of the huge quantities of so-called sulfite waste liquor from the wood-pulping industry, according to a paper presented by Dr. Irving A. Pearl and Donald L. Beyer of the Institute of Paper Chemistry, Appleton.

In the United States alone, sulfite mills discard more than 1,250,000 tons of lignin each year, the paper said, asserting that in lignin we have a raw material that potentially can rival coal tar or petroleum as a source of synthetic organic chemicals.

Explaining that under proper conditions of oxidation a substantial yield of vanillin can be obtained from lignin and sulfite waste liquor, the report said, although vanillin has been produced in large quantities in the past, all of it was consumed by the flavoring and perfume industries. The market was saturated and no increased production was indicated.

In view of this situation, long-range research on vanillin derivatives was begun with a view to developing new uses for vanillin, thereby stimulating the chemical industry and achieving greater utilization of the waste liquor which contains approximately 50 per

cent of the original wood in the sulfite pulping process.

The studies have developed a number of esters of vanillic acid which are useful in food preservation because they are non-toxic and check the growth of certain bacteria and molds.

Indications are that vanillic acid esters should prove very useful as sunscreens for sunburn prevention and for incorporation in plasticizers or softening agents, for transparent films and cellulose materials, the researchers reported. In addition, the physical properties of many of these materials should make them useful as plasticizers, and their nontoxicity should promote their usefulness in cosmetic preparations.

Alkyl-Lead Compounds

➤ AN INVESTIGATION of the physical and chemical properties of newly prepared compounds or of old compounds, study of which was neglected at the time of discovery, is always desirable in the opinion of George Calingaert, Hymin Shapiro, F. J. Dykstra, and Lewis Hess of the Ethyl Corporation Research Laboratories, Detroit, who presented a paper at a symposium on organometallic compounds. There is always the possibility that such study will suggest new and valuable uses for the materials.

The literature of the alkyl-lead compounds consists almost exclusively of preparative methods, with an occasional reference to physical properties such as melting and decomposition temperatures.

It appears wise to extend our knowledge of these compounds, say the authors, since they are interesting antiknocks for internal combustion engines. Since, however, they are known, in general, to possess relatively low orders of stability, it is necessary to determine under what conditions they are stable, before any significance can be attached to properties numerically described. This is the reason for the present investigation.

The mechanisms of the decomposition of the ethyl-lead chlorides, bromides, carbonates, and hydroxides on steam distillation were investigated. The bromides were also studied under conditions of spontaneous decomposition at room temperature.

It is noteworthy that, both at room temperature and at 100 degrees, the triethyl-lead halides decompose less rapidly than the corresponding dihalides, the chlorides being relatively more stable than the bromides, while the triethyl-lead hydroxide and carbonate decompose more rapidly than the corresponding diethyl-lead compounds.

Sound Waves in Chemistry

➤ SILENT SOUND waves have given chemists a new research tool for fast and accurate identification of complex liquid substances, Dr. Alfred Weissler of the Naval Research Laboratory, Washington, D.C., reported.

The velocity of sound passing through a liquid is determined by the chemical composition of the fluid, according to Dr. Weissler, who declared that this relationship can be calculated accurately in advance with the aid of mathematical formulas.

It is more convenient to utilize ultrasound instead of audible sound for this purpose, he explained, because, although ultrasound is pitched too high to be detected by the ear, it can be measured with compact instruments.

Investigations have been conducted on twenty substances with molecules consisting essentially of rings of carbon atoms plus, in some cases, oxygen, nitrogen, or sulfur. The studies have indicated that sound transmission is generally a more accurate means of identifying a liquid than refractive index.

The transformation of one chemical compound into another by intense ultrasonic waves was described in another paper presented by Dr. Weissler in collaboration with Herbert Cooper, also of the Naval Research Laboratory.

Iodine was found to be produced instantaneously upon ultrasonic irradiation of water containing dissolved carbon tetrachloride and potassium iodide, the chemists reported.

More than 1,000 experiments were carried out in order to measure how the amount of iodine formed depends on such factors as the container, the amounts of the various starting materials, duration of irradiation, accoustic intensity, and presence of dissolved atmospheric gases.

It was concluded that the fundamental chemical reaction takes place in two steps, each of which consists of breaking off two chlorine atoms from the carbon tetrachloride molecule.

The reaction does not take place, no matter how great the intensity of the sound, unless some gas is dissolved in the solution, the paper stated, explaining that the radiation converts the gas into bubbles, similar to the so-called cavitation bubbles formed by a whirling propeller.

The large mechanical or electrical forces which are produced at the collapse of cavitation bubbles are assumed to be the source of the considerable energy required to break chemical bonds.

Protective Plastics

➤ VERSATILE new plastic products which kill termites, prevent mildew and mold growth on cloth, and have many other industrial applications were described by Dr. Raymond B. Seymour, director of the Industrial Research Institute of the University of Chattanooga, and two associates.

The products can be employed as scavengers to remove harmful salts from water systems, as thickening agents for whipped cream, ice cream, or milk shakes, and even as stabilizers for mud in oil drilling.

The compounds were developed as the result of a study of the formation and properties of water soluble plastics containing acids. The investigators were able to determine the relative rate of formation of numerous plastics and to use the materials as textile sizings, and as moth, mildew, fungus, and water-proofing agents.

Reaction of these new compounds with chlorinated carbolic acid has produced water soluble compounds which kill termites in wood and prevent mildew and mold growth on cloth. Further treatment with metal salts such as mercury has made these products insoluble in the wood or on textiles, and thus they have become many times more effective. The addition of these derivatives to paper pulp has produced superior paper which does not have imperfections due to mold spots.

It was also found that these water soluble plastics would react with ethylene oxide, manufactured from natural gas, to produce other water soluble

plastics that can be used for coatings, synthetic fiber, and even in place of soap.

The original water soluble plastics produced very thick solutions, but the reaction products with ethylene oxide gave water solutions as thin as water itself. When these products were added to synthetic detergents, they increased their cleansing power.

Unlike most water soluble plastics, water solutions of these derivatives could be used as lubricants. Thus, they have value as cutting oils in metal working and as film forming lubricants in the textile industry.

Explaining that plastics are made by combining small molecules to produce larger molecules, the report said that in the work described the larger molecules were linked with a wide variety of compounds to produce many new materials of fundamental and practical importance.

Collaborating with Dr. Seymour in the report on "Copolymers of Vinyl Compounds and Maleic Anhydride" were Ira Branum, Jr., of the Industrial Research Institute, and Frank Harris of the University of Chattanooga.

Unscratchable Plastics

➤ SCRATCH-RESISTANT transparent plastics, hardest of their type ever made, have been developed at the Industrial Research Institute of the University of Chattanooga.

The new products, which also withstand heat and solvent chemicals, can be formed or moulded after manufacture with the same techniques that the aircraft industry employs in making bomber noses, according to a paper by Dr. Raymond B. Seymour, director of the institute, and Ira Branum, Jr., and Dr. F. W. Hayward of the Institute staff. Previously announced scratch-resistant materials could not be shaped after manufacture, it was said.

The researchers studied numerous clear plastics to appraise their scratch resistance and to develop methods of increasing their hardness. Progress in the work was determined by ascertaining the force necessary to cause a scratch of measured depth and by estimating the amount of haze developed when powdered abrasives were dropped on the plastic pieces.

The scratch-resistant products were made using techniques similar to those for making plastic sheets, but instead of using only methyl methacrylate small amounts of highly reactive materials were added and the liquid was changed to a solid sheet by heat.

The sheet was then immersed in solutions to form reaction products either on the surface or throughout the entire sheet under conditions that did not destroy clarity. Since the treated surface was actually part of the plastic held in chemical combination, the treatment is permanent. The techniques required no heat—merely dipping in or spraying on the solutions.

In addition to being more resistant to scratching than ordinary plastics, the new products are unaffected by solvents and are unusually resistant to heat.

In the course of the work, some beautiful blue and green plastics were developed. Unlike pigmented or dyed products, these colors are characteristic for the materials in much the same way that blue dyes are blue. However, most of the products were clear and colorless.

The investigation constituted one phase of a joint effort of the Industrial Research Institute and the Office of Naval Research, according to the paper, which had as its topic, "Surface Reaction of Copolymers of Methyl Methacrylate."

Waterglass Adhesive

➤ WATERGLASS, the cozy liquid once widely used to preserve eggs on the farm, has become an industrial chemical of constantly growing importance, said John H. Wills and Robert H. Sams of the Philadelphia Quartz Company, Philadelphia.

Chemically known as sodium silicate, and made of washing soda and sand, the material, although seldom recognized by the average person nowadays, is employed in freight-car quantities in many products and services, according to the report.

Five hundred million pounds a year of sodium silicate are consumed in a single field, the manufacture of paper mailing tubes, paper containers, and corrugated paper boxes. The chemical serves as the adhesive which holds the layers of paper together and seals the box flaps, and at the same time it lends rigidity and strength to the paper containers.

Because the boxes are produced at extremely high speed, often at the rate of 500 feet of board a minute, it is necessary that the adhesive change quickly from fluid to a hard, stiff solid capable of binding the paper into permanent position.

Chemical research has revealed how so rapid a change can be produced, the report continued. The adhesives are made by melting a mixture of sand and dry washing soda to form a glass which is soluble in water. The resultant solution has been found to contain a high concentration of small particles called hydrous silica. These particles, similar to dust specks in the air, have an electric charge, and may be thought of as little charged balls of filaments resembling wool fibers.

These particles, with their electrically charged filaments, can attach themselves readily to paper and other cellulose fibers, and can also adhere to glass and metal surfaces. When the water is drawn off by evaporation into the air or absorption into the paper, the residue becomes thicker, the particles are closer together, and they form a solid resilient mass. They will thus "set up" even though most of the water is still enmeshed between the particles and present as part of the particles themselves. For this reason, an initial set may occur very rapidly. To make it occur even faster, the report said, thick solutions may be heated to make them thin enough to work with, and the combination of cooling and a very small loss of water allows an exceedingly rapid initial set.

In recent years the papers used in making ordinary boxes have been radically changed. These papers now resist water more strongly; they have larger pore spaces which do not suck up liquids so rapidly. The larger spaces do, however, take up more adhesives. To meet these changes, it was found that a more dilute solution was needed to wet the paper fibers and to give a quick "grab." Such dilute solutions run away from the spot where the adhesive is needed. Special clays are therefore added as fillers to give the total mixture enough strength to stay where it belongs.

Research has sought out these properties and has shown how they apply

to commercial production processes. This research has helped box makers to keep up with the tremendous expansion of the demand for corrugated paper boxes without forcing the prices skyhigh or requiring investment in scarce heavy machinery and plant additions.

S-Polymers From Petroleum

➤ FRUIT, vegetables and tobacco can be kept fresh for six months or more in containers made of versatile new moisture resistant plastics described by Raymond G. Newberg of the Standard Oil Development Company's Esso Laboratories, Linden, N.J., and O. C. Slotterbeck of the Esso Standard Oil Company, New York, who presented a paper on "A New Series of All-Hydrocarbon Thermoplastic Resinous Copolymers."

Tests of the new chemicals, known as S-polymers, which are entirely derived from petroleum, have proved them ideal for packaging. In addition, the chemists said, the new resins have been found useful for cable insulation, electrical fixtures, toys, artificial leather, recording tape and records, gaskets, packings, tank linings, acid resistant clothing, electrotyping plates, and modifying agents for other resins and rubbers, and they are superior to wax in moisture-proofing paper because they do not crack when creased.

The packaging excellence of the S-polymers stems from their outstanding characteristic, resistance to moisture and gas penetration. Ripe grapefruit, oranges and lemons were wrapped in thin S-polymer films and kept for more than six months under ordinary atmospheric conditions at temperatures ranging from 70 to 95 degrees Fahrenheit and relative humidities from 50 to 100 per cent.

The fruits retained a high percentage of their vitamin content and were edible, the scientists declared. They exhibited no mold and gave off no offensive odors, and displayed the attractions of freshly picked fruits. Other investigations of similar nature were carried out on fresh vegetables, dried fruits and tobacco with equally interesting and comparable results.

Researchers have been pleased with the new resins because they can be blended, mixed, molded or pressed on conventional equipment now used in the plastics and rubber industries, because they keep their original appearance and properties after exposure to severe processing and aging conditions, and because they resist many chemicals ordinarily encountered.

The paper emphasized that the S-polymers are not universal plastics, but added: they have many attractive properties to recommend them, the most important of which are excellent processibility, usefulness in electrical equipment, outstanding resistance to the penetration of moisture vapor and gases, and ready compatibility with a large number of materials, including resins, rubbers, fillers and plasticizers.

New Method for CS_2

➤ A NEW, cheap method for producing carbon disulfide, a chemical essential in the manufacture of rayon, soil disinfectants, and many other products, was described by Dr. C. W. Siller of the New Jersey Zinc Company, Palmerton, Pa.

Explaining that the chemical can now be synthesized from hard coal and sulfur dioxide, a waste gas evolved in the smelting of ores of zinc, lead, copper, and other common metals, Dr. Siller declared that it is important that

a new procedure for making carbon disulfide has been developed, because the market for this chemical is increasing. Also, certain raw materials, such as hard wood charcoal, used in the present commercial process are becoming increasingly more difficult to obtain.

The largest consumers of carbon disulfide are the manufacturers of the viscose type of rayon, but the markets for carbon tetrachloride, freon refrigerating gases, soil disinfectants and other chemicals produced from carbon disulfide are expanding.

In the present commercial process for making carbon disulfide the raw materials are elemental sulfur and a reactive form of carbon, Dr. Siller said. The new process should find acceptance in locations where either or both of these raw materials are not plentiful.

In the new method, sulfur dioxide gas is piped into a tube packed with hard coal and heated to more than 1,000 degrees Centigrade, 90 per cent of the sulfur dioxide being converted to carbon disulfide. If carbon monoxide is burned to furnish heat for the reaction, the process can be made continuous and automatic.

In a recently developed electrical process for manufacturing carbon disulfide, a cheap source of electricity is necessary for economical operation, Dr. Siller stated, pointing out that this factor alone often determines the site of the plant. If the new method is used, much greater latitude is allowed in the selection of a factory location.

Polyisobutylene

➤ FACE CREAM, machine grease, rubber, and paint can all be made from a single chemical, polyisobutylene, one of the most versatile synthetic materials, according to Vanderveer Voorhees, senior patent attorney of the Standard Oil Company (Indiana), Chicago.

The most important current use for polyisobutylene is in butyl rubber, which is widely employed for inner tubes of automobile tires because it holds air better than natural rubber. But a survey of the patent literature shows that polyisobutylene can be made into an enormous variety of products useful in everyday life.

Polyisobutylene, which is made from gases evolved in the refining of petroleum, ranges in consistency from a sticky grease to a rubbery solid, depending upon the conditions under which it is produced, Mr. Voorhees explained, and through chemical modification it can be converted into hard plastics and paints.

Among the many polyisobutylene products already patented are: grafting wax for splicing tree branches, cosmetics, plastic adhesive tape, electrical insulation, dripless oils for textile machines, paints that resist corrosive chemicals, and a chemical agent for improving the performance of diesel engine fuel.

The unusual chemical stability of polyisobutylene, which approaches that of paraffin wax, makes it a suitable material for many special uses where resistance to acid and oxidation is essential. Another useful feature is that when it is dissolved in oils, the resulting greases do not drip, although they flow readily under slight pressure, he said, pointing out that this makes these compounds particularly valuable for certain purposes, including textile machinery lubricants that do not soil thread and cloth.

"In an age remarkable for many amazing products of organic chemistry, such as nylon, buna rubber, neoprene, methacrylate and alkyd resins, and a host of other plastics, there is probably no material more interesting than the polyisobutylenes," Mr. Voorhees declared.

Although polyisobutylene was discovered in Russia in 1873, no further interest seems to have been shown in the material until the 1920's, according to Mr. Voorhees, but in the period since 1930, more than 200 United States patents have been obtained, the majority relating to uses of polyisobutylene in which its special properties are advantageous.

Explaining that polyisobutylene consists of molecules of a gas, isobutylene, strung together in long chains, he said that an unusual feature of the manufacturing process is the tremendous speed of reaction at extremely low temperatures.

At 80 degrees below zero Centigrade the process may be complete in less than five minutes, during which time giant polyisobutylene molecules are formed, each containing more than a thousand isobutylene molecules.

Since best results are obtained at such low temperatures, adequate refrigeration is important, he stated, and one patent calls for the use of dry ice.

Team Mate for DDT

➤A NEW CHEMICAL weapon against insects which may be teamed with DDT in apple orchards this summer was described by scientists at the eastern meeting of the American Association of Economic Entomologists.

The new insecticide will kill mites which survive DDT. In apple orchards, these mites, sometimes called "little red spiders" though they are not spiders, multiply rapidly when DDT kills the insects which normally feed on mites. The new chemical can rid orchards of these pests.

Chemists call the insecticide O,O-diethyl O-p-nitrophenyl thiophosphate. Its shorter trade name is thiophos 3422. Scientists of the American Cyanamid Company's agricultural chemical division, where the insecticide was developed, say that it has killed all species of mites and insects tested.

U.S. Department of Agriculture scientists who have experimented with the new chemical reported that it will probably be used as a team mate of DDT. They explained that it has a strong odor which makes it more suitable for outdoor jobs such as in the orchard than for use in the home or greenhouse.

Another use of thiophos 3422 may be against aphids. Nicotine, now commonly used against these pests, has been in short supply.

Reported here for the first time, the new weapon against insects and mites has been tested last year at approximately 75 agricultural experiment stations. Some of this work was described to entomologists at the meeting.

The insecticide will be manufactured in commercial quantities this year, but a heavy demand which will make the supply of the chemical limited already is predicted.

New Poison Baits Against Your Rats

Rat-Killing Chemicals

by Dr. Frank Thone

➤ Rats, which can kill you with any of a dozen germs, can themselves be killed with several weapons that are at your disposal. Some are old, but still effective. Some are new—and nothing short of sensational in their deadliness to rodents.

ANTU and 1080 are the ones that are being most talked about at present. Both are synthetic chemicals, born of the wartime need to find replacements for overseas supplies of red squill and other time-tried rodenticides made scarce by lack of shipping. They are in a way complementary to each other; for while ANTU is suitable for use by the individual householder or farmer, 1080 is so terrifically lethal that only trained professional operators should use it. Of course, professional rat-killers use ANTU as well.

Discovery of ANTU grew out of a laboratory mishap. Dr. Curt Richter, a psychologist at the Johns Hopkins Hospital, was interested in a chemical named phenyl thiourea, which to some persons is extremely bitter but to others quite tasteless. He wanted to find out if this "taste-blindness" existed in animals, and tried it first on rats. He had to give up the experiment because the rats all died.

Although the experiment was not a success psychologically, Dr. Richter was quick to see other possibilities. He hunted for a related compound that would be tasteless, yet just as lethal to rats. Presently he found it, in alpha naphthyl thiourea—by initials, ANTU. After full tests had shown its effectiveness, commercial production was undertaken by du Pont.

One of the really good things about ANTU is its relative harmlessness to practically all animals except brown rats and (to some extent) house-mice. It will not even poison black rats. Domestic animals and human beings seem able to swallow considerable quantities of it without harm. It is therefore one of the safest of all rat poisons to have about the place.

ANTU powder can be used against rats in four ways: sprinkled on water —for it is not very soluble; mixed with ground meat, fish or other foods; rubbed on cheese or bacon rind; sprinkled dry in runways, so that the rats will later lick it off their feet. There is also an ANTU paste, for spreading on crackers, cheese or other baits.

Use of ANTU or other rodenticide with water is always recommended. Rats are thirsty animals, and as a rule water is not easily accessible, so small quantities of poisoned water are eagerly taken. It is always well to set out your poison in two or more ways —water baits, plus properly prepared food, plus sprinkled runways.

Always use plenty of poisoned baits the first time. In anti-rat war, as in

➤ YOUR RAT—*there is one for every man, woman and child in the United States—is robbing the world of food that cannot be spared. New chemicals bring hope of exterminating these dangerous pests.*

human warfare, "blitz" attacks are best. If there are any survivors after the first night or two of poisoning, they are apt to become very chary of free handouts of food and water. The enemy isn't stupid: don't underrate a rat.

Also, the best way to attack the rat problem under ordinary city conditions is to get all the neighbors organized, and clean up the whole block at once. This was the method adopted in Baltimore when ANTU received its first practical try-out. Rats will migrate readily from house to house within a block, but a street seems to be a natural frontier in ratdom, and the inhabitants are a bit hesitant about crossing it. At any rate, if an entire block, or an area of several blocks together, is de-ratted at once, it is usually not reinfested for a considerable time.

While ANTU is sold freely to any adult who wants to deal with his own individual rat problem, 1080 is quite another story. That is distributed only to professional pest eradicators and

to public officials. Unlike ANTU, which is poisonous practically only to brown rats, 1080 is deadly to all common animals and to man as well. Worse still, there is no proven antidote. The one reported case of recovery after 1080 poisoning was of a baby who accidentally got hold of some 1080 solution, and was just barely pulled through by phenobarbital followed by continued dosing with whisky. Fortunately, authorized users of 1080, thoroughly aware of its deadliness, have been so cautious that accidental poisonings, even of domestic animals, have been very rare.

Discovery of 1080 resulted from a careful and systematic war-time search, conducted by scientists of the U. S. Fish and Wildlife Service for O.S.R.D. They tried out more than a thousand different chemicals on laboratory rats. One bottle, bearing the serial number 1080, contained the stuff that did the trick — sodium fluoroacetate. It has no odor, no taste that a cautious human tongue can perceive, but it is a toxicological high explosive. Rats that ate a few millionths of their body weight in the new compound became paralyzed in 20 minutes, were dead in half-hour.

So lethal is the stuff that no chemical company really wanted the job of making it. Monsanto finally accepted the undesired monopoly. The production plant was put away out in the country, on the remotest corner of their most isolated property.

None but professionals are permitted to handle 1080, and they work as gingerly as do handlers of radioactive isotopes. The official publication of the National Pest Control Association suggested that only water baits be used, in tiny paper cups that hold only a spoonful or so. Food baits might be picked up by pets or poultry. It was further recommended that the bait cups be numbered, and that no operator leave the premises where he was working until all numbers were accounted for.

There are some other highly toxic compounds that have been discussed for possible use in rat campaigns. One German chemical, trade-named Castrix, received considerable publicity during the winter; one or two organic phosphorus compounds have also been mentioned. But these are all so highly toxic that they rank with 1080 in handling hazards, and their commercial production and use is not now contemplated. Of the newer weapons available, ANTU and 1080 seem to be the present favorites.

Rats can be effectively killed with some of the older, time-tested weapons as well as with the new ANTU and 1080. Red squill is still too good a means of destruction to be omitted from the anti-rat arsenal, and traps still have their uses.

Red squill, in fact, is so good that if it had not been for the war it would probably still be the number one weapon in the war on rats. But because it comes from the Mediterranean region, and because the Mediterranean sea was not a good commercial highway for several years, synthetic substitutes had to be sought. And as sometimes happens, the substitutes turned out so well that replacement became permanent, at least in part.

Red squill powder is back on the market now; but it is well, in pur-

chasing it, to make sure of its potency. It comes from the Near East — and Levantine traders are not always above rooking the foreigner with substandard wares if they think they can get away with it. However, if you can be assured of the drug's quality, you will have a really good rat-killer.

The product you find on the market is made of powdered scales of a lily-like bulb—the plant is also known as "sea onion." It belongs to the lily family, and is a botanical second cousin of the blue squill that is among the prettiest of early spring flowers in our gardens.

Curiously enough, this plant that is deadly to rats has long been used in human medicine. Sirup of squill is a popular croup remedy, and still figures in certain proprietary cough cures. Naturally, in these medicinal preparations the dose is kept far below the rat-killing level.

However, there need be no great fear of ill consequences if young children get hold of red squill in its rat-killing form, or of the family dog or cat finding meat or cheese rat-bait with the poisonous powder on it. For while it is poison, it is also an emetic; a child or pet swallowing it will get sick and "throw up," thereby avoiding worse effects. But rats are so constructed that they cannot vomit; once they swallow red squill they can only hold it until it kills them.

There are several general poisons that had their turn at being rough on rats a generation or two ago—strychnine, arsenic, phosphorus paste, and a little later, thallium compounds. All these have the drawback of being dangerous to pets as well as to incautious members of the family. Furthermore, they often warned the wiser rats either by taste, as with strychnine, or by odor, as with phosphorus. So while some of them still enjoy a certain amount of favor in rodent-control work on the range they have been steadily declining in house-pest eradication use.

Two other methods have sometimes been recommended, though neither could properly be classified as a poison. One is to mix dry plaster-of-paris in cornmeal, flour or similar bait. The idea is that the plaster would form a solid, hard mass in the rat's digestive tract and so kill him. The other idea is to jam the rat's burrows with broken glass, with the hope of cutting the animals' legs and feet. Scientists who are directing the present nation-wide anti-rat drive are not enthusiastic about either of these methods.

There remain traps. These have limited usefulness, for most of them are good for only one victim a night; and there are always clever or suspicious rats that manage to keep out of them — or even to get out, in the case of the old-fashioned cage trap. The jaw-trap, placed on the rat's runway and sifted over with such cover as oats or torn paper, is usually a sure catch when it is sprung. But it holds the animal only by the leg, and you are up against the nasty job of killing the rat when you find him.

Probably most satisfactory of all types is the spring trap that slams a strong, square-ended wire loop down on the rat, and if it hits him squarely kills him instantly by breaking his

spine. This can either be baited or placed without bait across a runway or at the entrance to a burrow. One ingenious trick is to nail up such a trap just under a rat-hole that is a few inches above the floor. Even wary rats, that have learned to avoid rat-traps placed flat on the floor, do not expect to find one on the wall and so trip the fatal trigger before they realize their danger.

An interesting recent variant of this trap is an all-metal one, with a saucer-like depression in its base to hold water and a perforated treadle over it. This takes advantage of the rat's thirstiness, already noted in connection with the use of poisons.

Whether you are using poisons or traps, and whether your bait is food or water, it always helps to make other food and drink as scarce as possible. Don't leave anything edible or drinkable within the rat's reach. Lock up food in the refrigerator, or in tight-lidded cans and breadboxes. Empty boxes of cereal, dried beans and peas, and the like into screw-topped glass jars. Then place your poison or set your traps, and you will be much more likely to have plenty of takers.

► THE END *of one night's attack, in a city market, with the new chemicals had this much to show for their effectiveness against rats, one of man's deadliest enemies.*

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